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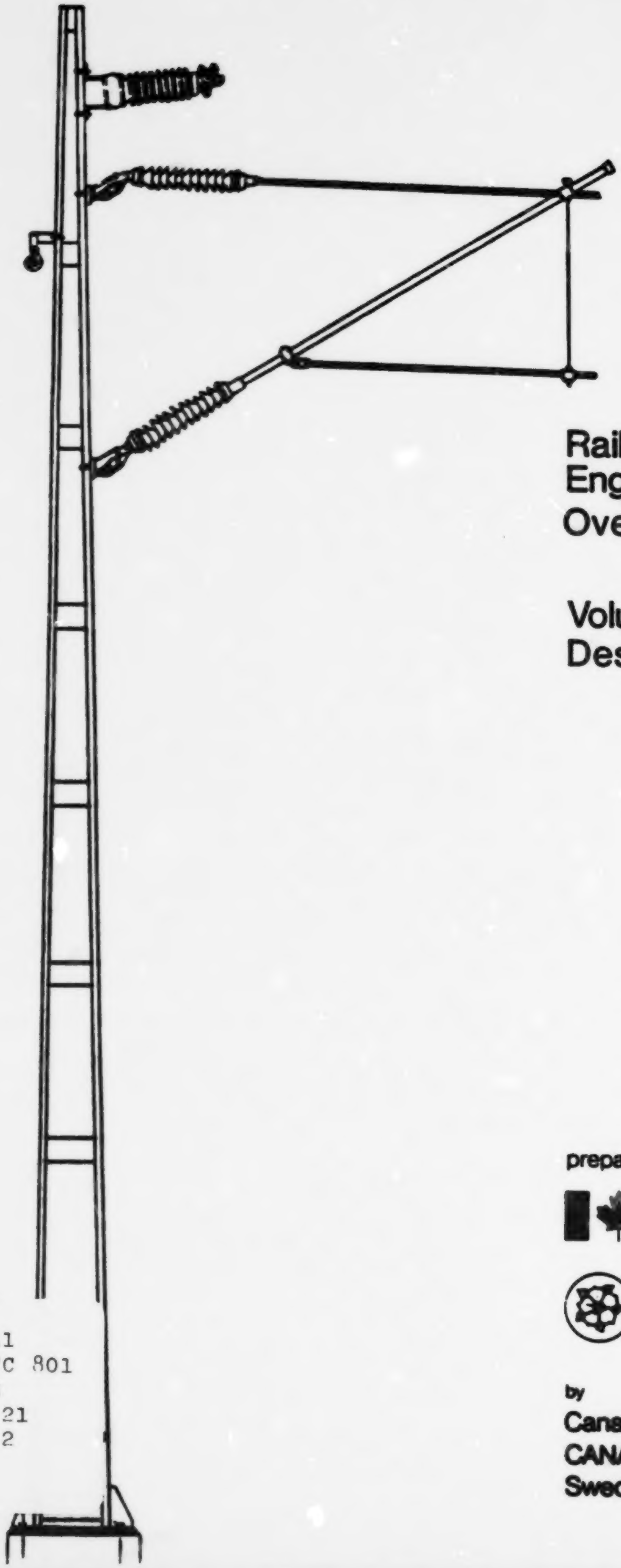

Railway Electrification Engineering and Sourcing Overhead Contact System

Volume I
Design and Procurement Report

prepared for

Transportation Development Centre
Transport Canada

BRITISH
COLUMBIA
RAILWAY

by

Canadian Pacific Consulting Services Ltd.
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RAILWAY ELECTRIFICATION
ENGINEERING AND SOURCING
OVERHEAD CONTACT SYSTEM

VOLUME I: DESIGN AND PROCUREMENT REPORT

Based on data obtained from
ELECTRIFICATION OF THE BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE

Canadian Pacific Consulting Services Ltd.
Montreal, Canada
October 1983

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of Transport Canada, Transportation Development Centre.

PROJECT TEAM

The project team was comprised of personnel from the following organizations:

Canadian Pacific Consulting Services Ltd.
CANAC Consultants Limited
Swedish State Railways
International Engineering Company Ltd.

Foundation Design done by BCR Engineering Staff
Procurement done by BCR Material Management Staff

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REPORT DOCUMENTATION FORM

1. Transport Canada Report No.
TP 4950 E

2. TDC Project No.
4760/61

3. Recipient's Catalogue No.

4. Title and Subtitle
Railway Electrification - Engineering and Sourcing
Overhead Contact System
Volume I: Design and Procurement Report

5. Report Date
October 1983

6. Performing Organization Report No.
C-82079

7. Author(s)
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8. Transport Canada File No.
D1465-317-10

9. Performing Organization Name and Address
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10. DSS File No.
11SD.T8200-2-2519

11. DSS or Transport Canada Contract No.
0SD82-00111

12. Sponsoring Agency Name and Address
Transportation Development Centre
1000 Sherbrooke Street West, Suite 2421
Montreal, Quebec H3A 2R3

13. Type of Report and Period Covered
Final, November 1983

14. Sponsoring Agency Code

15. Supplementary Notes
Volume II: Material Specifications
Volume III: Component and Assembly Drawings

16. TDC Project Officer
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17. Abstract

This report covers the engineering and sourcing information for an overhead contact system based on the data obtained from design and procurement for the electrification of the British Columbia Railway Tumbler Ridge Branch Line.

The report includes a summary of all design details including technical specifications for all material and design drawings for all components and parts requiring special manufacture or fabrication.

Copies of all material specifications have been compiled in a separate volume because of their bulk. Volume II of this report is dedicated to those specifications.

For ease of publication, all design drawings have been compiled in a separate document which is available as Volume III of this report.

The report also includes summaries of procurement data for all material required for the electrification of the Tumbler Ridge Branch Line, from which several conclusions are derived such that the cost of future electrification projects using the same or similar designs can be costed with reasonable accuracy.

18. Key Words
Railway Electrification
Overhead Contact System
Design and Procurement

19. Distribution Statement
A limited number of copies are available from the sponsoring agency.

20. Security Classification (of this report)
Unclassified

21. Security Classification (of this page)
Unclassified

22. No. of Pages
174

23. Price
Nil

TDC/CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada
TP 4950 E

2. N° de l'étude — CDT
4760/61

3. N° de catalogue du destinataire

4. Titre et sous-titre
Railway Electrification - Engineering and Sourcing
Overhead Contact System

Volume I: Design and Procurement Report

5. Date du rapport
octobre 1983

6. N° du rapport de l'organisme exécutant
C-82079

7. Auteur(s)
M. Sugimoto
L.C. Tait

8. N° de dossier Transports Canada
D1465-317-10

9. Nom et adresse de l'organisme exécutant
Société d'études et de consultation du
Canadien Pacifique (Ltée)
740 ouest, rue Notre-Dame, suite 760
Montréal, Québec H3C 3X6

10. N° de dossier — ASC
11SD.T8200-2-2519

11. N° de contrat — ASC ou Transports Canada
0SD82-00111

12. Nom et adresse de l'organisme parrain
Centre de développement des transports
1000 ouest, rue Sherbrooke, suite 2421
Montréal, Québec H3A 2R3

13. Genre de rapport et période visée
final, novembre 1983

14. Code de l'organisme parrain

15. Remarques additionnelles
Volume II: Material Specifications
Volume III: Component and Assembly Drawings

16. Agent de projet — CDT
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17. Résumé

Ce rapport contient les données sur le design et l'information sur la provenance du matériel pour le système de contact aérien pour l'électrification de la ligne de Tumbler Ridge du B.C. Rail.

Le rapport comprend tous les détails de la conception ainsi que les spécifications techniques de tout le matériel et les dessins pour toutes les pièces ou composantes qui demandent une fabrication spéciale.

Les copies des données relatives aux spécifications des matériaux étant volumineuses, elles ont été incluses dans un volume séparé, notamment le volume II du présent rapport.

On trouvera également tous les dessins de conception au volume III de ce rapport.

On trouvera aussi dans le rapport et sous forme de sommaires, les données relatives à la fourniture des matériaux requis pour l'électrification de la ligne de Tumbler Ridge de B.C. Rail. Plusieurs conclusions sont tirées de ces sommaires qui permettront de faire des estimés relativement précis pourront être faits pour les projets d'électrification utilisant des systèmes du même genre.

18. Mots-clés
Electrification des chemins de fer
Système de contact aérien
Conception et fourniture

19 Diffusion
Un nombre limité de copies peuvent être obtenues de l'organisme parrain

20. Classification de sécurité (de ce rapport)
Aucune

21. Classification de sécurité (de cette page)
Aucune

22. Nombre de pages
174

23. Prix
-

CDT TDC 79-005

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the advice, assistance and data provided by the personnel of British Columbia Railway, in particular the Chief Engineer, Mr. V.W. Shtenko, and his engineering staff; and the Materials Manager, Mr. E.K.A. Focke and his Material Management staff.

RAILWAY ELECTRIFICATION
ENGINEERING AND SOURCING
OVERHEAD CONTACT SYSTEM DESIGN & PROCUREMENT

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RAILWAY ELECTRIFICATION
ENGINEERING AND SOURCING
OVERHEAD CONTACT SYSTEM DESIGN & PROCUREMENT

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- Electrical Components and Assemblies
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OVERHEAD CONTACT SYSTEM DESIGN REPORT

1. INTRODUCTION

1.1 BACKGROUND

The British Columbia Railway's (BCR) Tumbler Ridge Branch Line (TRBL) runs from Anzac, on the BCR mainline north of Prince George, to the Tumbler Ridge area through mountainous terrain, and includes two major tunnels with a total length of approximately fifteen kilometres, two minor tunnels, eleven bridges, and connections to loadout loops at two coal mines.

BCR's decision to electrify the TRBL was the result of an electrification study prepared by Canadian Pacific Consulting Serivces (CPCS) Ltd. and CANAC Consultants Limited (see Transportation Development Centre Report No TP 3619 E entitled "Electrification Study for British Columbia Railway Tumbler Ridge Branch Line" published in May 1982). CPCS, in association with CANAC and Swederail Consulting AB were retained by BCR to complete, among other things, the detailed design of the overhead contact system for the TRBL.

The design and material sourcing of components for the overhead contact system is of direct interest to the Transportation Development Centre of the federal government which has retained CPCS to prepare this report.

1.2 PURPOSE

The purpose of this report is to document the engineering and sourcing of materials for the overhead contact system (OCS) as designed and procured for the BCR TRBL.

1.3 METHODOLOGY AND APPROACH

The design and sourcing of materials for the overhead contact system for the BCR TRBL was based on designs tried and proven by the Swedish State Railways (SJ) in climatic conditions very similar to those in northeastern

British Columbia. The SJ designs were adapted for the relatively slow speed, high tonnage unit coal train requirements of BCR, and the environmental conditions that exist in the area of the TRBL.

Based on the results of earlier investigations, the OCS operating voltage of 50 kV (nominal) supplied from a commercial 60 Hz source was selected. As a result of voltage regulation studies, it was decided to insert a series capacitor station approximately mid-way (km 67) along the line to reduce the inductive reactance of the OCS. Details are described in the Power System Design Report No. TP 4899 E which is not included in this report.

Because of the long tunnels on the line, the OCS required some different components in the interior of the long tunnels as compared to the exterior. The design of the OCS inside the tunnels was based on a conceptual design derived by the International Engineering Company Inc. (IECO) during an earlier investigation.

2. BASIS OF DESIGN AND RELATED REPORTS

2.1 SITE SPECIFIC DETAILS

The TRBL and the operation of unit coal trains on that line are described in TP 3619 E. The detailed description of the line and its operation are not repeated in this report.

2.2 CONCEPTUAL DESIGN

The detailed design of the OCS was an extension of the conceptual design established during an earlier phase. The conceptual design report is included in its entirety as Appendix 1 to this report. It documents the basis of the detailed design of the OCS for the BCR TRBL. The physical, mechanical and electrical characteristics of the OCS are described, as are the climatic conditions of wind, ice loading and temperature variations for which the OCS has been design to meet. These details are not repeated elsewhere in this report.

2.3 OCS IN THE LONG TUNNELS

The detailed design report on the overhead contact system in the long tunnels has been prepared by IECO and the main body of their final design report is included as Appendix 2 to this report. It summarizes the design work performed by IECO on the electrification of the portions of the TRBL which pass through the two long tunnels. Of particular interest are those parts of the report which describe the fixed termination catenary design and its support brackets and cantilevers.

2.4 OCS FEEDER AND POWER SUPPLY DETAILS

The design of the 50 kV feeder line, the power supply, harmonic filters, and series capacitors is closely allied to the design of the OCS, but the details are not included in this report. They will, however, be documented and published in Transportation Development Centre Report No. TP 4899 E entitled "Tumbler Ridge Branch Line Electrification Power System Design".

3. DESIGN DRAWINGS AND MATERIAL SPECIFICATIONS

3.1 DESCRIPTION

The design drawings included in this report are limited to the component and assembly drawings of specially manufactured/fabricated components and assemblies. Site specific design details such as construction layouts for the OCS have been excluded from this report. The originals of these drawings are of varying sizes. For ease of publication, all drawings larger than an A3 size have been reduced to that size (285 mm x 390 mm). Reproducible copies are held by TDC from which prints can be produced bound to form Volume III of this report.

3.2 DRAWING CATEGORIES

The drawings are grouped into the following categories:

a) OCS Support Poles
b) Support Pole Foundations

c) OCS Manufactured/Fabricated Components and Assemblies
d) Special Tunnel OCS Hardware Components and Assemblies

3.3 LIST OF DRAWINGS

A total of 280 drawings are included in Volume III of this report. Drawing numbers and titles are listed in Appendix 3 of this report.

3.4. MATERIAL SPECIFICATIONS

Where the drawings alone contained insufficient details to permit procurement of materials, detailed material specifications were prepared. These specifications, together with the design drawings where applicable, formed the technical input for the sourcing of the material required for the electrification of the TRBL.

3.5 LIST OF MATERIAL SPECIFICATIONS

Copies of all material specifications are included in Volume II of this report. As with the design drawings, the material specifications have been compiled in a separate volume because of their bulk. The specifications included in Volume II are listed and described briefly in Appendix 3 of this report.

4. MATERIAL SOURCING

The material covered in the drawings (discussed in Section 3) was specified for ease of presentation from an engineering design point of view. In many cases, it was desirable, if not necessary, to group the material into different groupings for sourcing and procurement. The material was therefore tendered in the following groupings or categories.

a) Poles
b) Pole Foundation Material
c) Portals
d) Hardware
    i) Special castings and fabricated components

    - ii) Insulators
    - iii) Tubing
    - iv) Miscellaneous hardware
    - v) Nuts and bolts
    - vi) Tunnel hardware
- e) Wire, Fittings, and Clamps
    - i) Copper and ACSR
    - ii) Steel rope
    - iii) Wire fittings
    - iv) Clamps
    - v) Droppers

For ease of presentation and discussion in this report, the following categories or groupings have been chosen:

a) Support Structures: including poles, foundations and portals, i.e., the structures to which the next category (mechanical components and assemblies) can be attached.

b) Mechanical Components and Assemblies: including, by arbitrary definition, all those components and assemblies (which attach to the support structures and) which are required to secure the next category (electrical components and assemblies).

c) Electrical Components and Assemblies: including, by arbitrary definition, all those components and assemblies (such as wires, droppers, section insulators) which are required along the span between support structures, as well as those required at the support structure on an "as required" basis (such as overlap jumpers, ground wires to the rails, disconnectors, etc.).

5. SUPPORT STRUCTURES

5.1 POLES

Four sizes of poles were required to cater to the various loadings encountered on the TRBL. The four types and an extension are as follows:

POLE TYPE	ABBREVIATED DESIGNATION	DRAWING NUMBER
C130 x 10	C10	C-82079-02-001
C130 x 13	C13	C-82079-02-001
C150 x 16	C16	C-82079-02-002
C250 x 30	C30	C-82079-02-005
Extension	Ex	C-82079-02-006

The material required was tendered in December 1982; nine manfacturers responded. The following is a summary of costs based on quotations for short poles mounted on separate foundations.

POLE TYPE	HIGH	LOW	AVERAGE	CONTRACTED PRICE
C10	$460	$341	$410	$340.78 EBCO
C13	$536	$415	$485	$415.24 EBCO
C16	$607	$491	$552	$490.85 EBCO
C30	$1,110	$882	$969	$882.45 EBCO
Ex	$214	$ 85	$136	$111.42 L.A. Steel

The poles are described in greater detail in Appendix 5. Further sourcing details are also provided.

5.2 POLE FOUNDATIONS MATERIAL

The foundations were designed by BCR and the design details are contained in the BCR report included in Volume II. Three types of foundations were required to cater to the various soil and rock conditions along the grade of the TRBL. In brief, the three types are:

a) Type I - H-Beam Piles - Drawing No. A2/7-21466 and 482

b) Type II - Precast Concrete Pedestals - Drawing No. A2/7-21457 and 21458

c) Type III - Rock Anchors - Drawing No. A2/7-21466 and 482

The material required for the three types of foundations was requisitioned in four parts as follows:

a) Precast Concrete Pedestals

b) H-Beam Piles

c) Footing Plates

d) Bolts, Nuts and Washers

Sourcing and cost summaries are detailed in Appendix 6. The material costs vary somewhat depending upon not only the type of foundation, but also as the type of pole to be installed on that foundation. A wide variation in installation costs can be expected depending upon the type of foundation required. In order to present a clearer picture of costs, the costs of installed foundations and poles has been included in Appendix 6.

5.3 PORTALS

The portal designs are discussed in detail in Appendix 5. The portal is designed as a four-part structure with varying lengths of each of the four parts. The standard portal for a three-track span on the TRBL uses a four part structure totalling 17 metres. A few spans required 18 metre structures and 19 metre structures.

A total of 23 firms responded to the request for quotations. The variations between the lowest 14 have been tabulated in Appendix 5. The cost of material for a 17 metre span varies from a low of $1,907.57 to a high of $3,274.13 with the average at $2,618.24. The contracted cost was $2,090.53.

5.4 SUPPORT STRUCTURE SUMMARY

The cost of poles varies by as much as a factor of 2.5 depending on the type of pole required, which in turn is very much a function of site-specific track layout details (as is the requirement for portal structures).

The cost of foundation materials varies by as much as a factor of 3.4 depending on the type of foundation required, which in turn is very much a function of site-specific soil conditions along the grades as well as the size of pole which the foundation must support.

The effect of these variations tabulated in the summary showing installed costs of poles and foundations (see Appendix 5). A net variation of 1.8 to 2.0 can be expected due to site-specific requirements. Given sufficient details on the track layout and the soil/ rock conditions along the grade, the types and numbers of portals and pole/foundation combinations can be estimated and unit costs can then be applied to establish an estimate of total support structures costs (see Section 8 of this report for further comments on support structures).

6. MECHANICAL COMPONENTS AND ASSEMBLIES

6.1 SPECIAL CASTINGS AND FABRICATIONS

The special castings and fabricated components and assemblies for the OCS were specified in "sets" of components to ensure proper fit of mating components. The specification for this hardware includes detailed descriptions of 37 sets, and simple sketches of the major assemblies are included to depict the relationship of the sets and the individual components. The 37 sets require 75 individual components or minor assemblies, 30 of which involve castings. The detailed drawings are listed in Appendix 6 and included in Volume III of this report.

For procurement purposes, the sets or individual components were grouped into packages representing functional groupings of assemblies and individual components. The response from industry is therefore analyzed on a package-to-package basis and subsequently on a total order basis (see Appendix 6 for further details). Unit costs derived from this data for the major assemblies (such as cantilevers, weight tensioning units, mid-point anchors, etc.) are discussed in Section 8 of this report.

6.2 INSULATORS

The insulators considered in this category consist of: the cantilever rod insulators (upper and lower); the feeder wire line post insulators; and the station post insulators used on the tunnel cantilevers. (Suspension insulators for terminating the contact, messenger and feeder wire are also considered since they formed part of the insulator procurement package, but these have been considered as part of the electrical component and assembly category or grouping - see Appendix 7).

The cantilever rod insulators require special end caps and procurement of these insulators from off-shore (NGK) proved considerably less costly than North American procurement. The line post and station post insulators, on the other hand, were off-the-shelf items (from a design point of view) and O.B. Canada offered the best prices.

6.3 CANTILEVER TUBING

With the exception of cantilevers used in the tunnels, all cantilevers utilize varying lengths of some or all of the following sizes of tubes: 54 mm, 44 mm and 27 mm outside diameter tubing. The length of tubing required is determined from cantilever sets which are designated by numbers on the site-specific layout drawings. The dimensioning and material specifications for the tubing have been based on the Swedish design resulting in the requirement for tubing materials and sizes which are not common in North America. Time constraints on the design and implementation of an electrified Tumbler Ridge Branch Line for BCR precluded a new design based on North American standard tubing sizes and materials (castings and fittings would have to be redesigned to be compatible with the tubing). European sources of the tubing are, however, available and costs are extremely reasonable. (See Appendix 6 for further details). From the summary at the end of Appendix 6, it will be noted that tubing costs are approximately 5% of the total mechanical component and assembly costs.

6.4 MISCELLANEOUS HARDWARE

Miscellaneous hardware refers to several items of standard off-the-shelf hardware such as guy rods, anchors and exothermic connectors. The bulk of these were specified in a separate specification. Most of this material was specified by manufacturer's part or catalogue number or equivalent. Appendix 6 provides further details, and the summary at the end of Appendix 6 indicates that such hardware amounts to less than 4% of the total required for mechanical components and assemblies.

6.5 NUTS AND BOLTS

Nuts and bolts are considered to be in the same category as miscellaneous hardware. With the exception of special J-hooks (see Dwg. No. 4-503109 and 4-503110), the nuts and bolts are an accumulation of all standard off-the-shelf hardware used throughout the OCS. To facilitate economical procurement, a separate specification addressed the total requirement. Appendix 6 provides further details, and the summary at the end of Appendix 6 indicates that nuts and bolts amount to a significant 6.52% of the total mechanical component and assembly cost.

6.6 WIRE ROPE

Because of the particular requirements of the stainless steel wire rope used on the weight tensioning assemblies, this material was specified and procured separately. The overall cost amounts to a minor portion of the total mechanical component and assembly cost (approximately 0.54%). See Appendix 6 for further details.

6.7 TUNNEL HARDWARE

Various steel members unique to the overhead contact system in the tunnels were specified and procured as a separate package. The two long tunnels and two short tunnels on the BCR Tumbler Ridge Branch Line make up approximately 16 route (and track) kilometres of the line. Appendix 6 provides further details and the summary indicates that this package makes up 4.21% of the total mechanical component and assembly cost.

6.8 MECHANICAL COMPONENTS AND ASSEMBLIES - SUMMARY

The table at the end of Appendix 6 summarizes the cost information on the eight segments, making up this category or grouping. On the basis of total contract orders, it can be seen that two items make up the bulk of this category: special castings and fabrications at 47.85%; and insulators at 30.97%. The remaining 21.18% is made up by the requirements for tubing, miscellaneous hardware, nuts and bolts, wire rope, tunnel hardware and guy wires (nuts and bolts make up a surprising 30.8% of that total). Appendix 8 deals further with this category in the context of the total OCS.

7. ELECTRICAL COMPONENTS AND ASSEMBLIES

7.1 WIRE

Appendix 7 addresses the design and procurement aspects of all wires and cables required for the OCS. The 107 mm^2 Copper Trolley wire which is used for the contact wire is strung without splices wherever possible. For that reason, the material requirements for the contact wire are specified by reel lengths to fit the lengths of the sections as dictated by the site-specific construction layouts. In that sense, the material requirements for the contact wire are site specific. However, the total cost of the contact wire can be estimated with considerable accuracy based on the length of track to be electrified, provided that adequate allowance has been made for overlaps and wastage. Based on the data contained in Appendix 7, it is evident that the variation in wire prices is less than the price variation for any other category of material for the OCS, and it is also evident that some 28.0% allowance was needed, in the case of the BCR Tumbler Ridge Branch Line electrification, for overlaps and wastage.

The messenger wire can be spliced without detrimental effects, however, for ease of stringing the wire, it is advantageous to order the wire in similar reel lengths to the contact wire. The earth and feeder wires are strung as continuous fixed-termination installations, and therefore, variable reel lengths are not required and the requirements for, and cost of, this wire can be established with great precision based on the track kilometres to be electrified. The remainder of the wire requirements such as jumper wire, dropper wire, and ground wire are best estimated on a per kilometre basis. See Appendix 7 for further details.

7.2 WIRE FITTINGS

Wire fittings such as joints, splices, etc. are all off-the-shelf items specified by manufacturer's part or catalogue number (or equivalents). Appendix 7 provides further details. The cost of wire fittings makes up less than 2% of the total cost of all electrical components and assemblies. In the summary of the end of Appendix 7, this cost has been combined with the cost of clamps (discussed in Section 7.3).

7.3 WIRE CLAMPS

Wire clamps in this category are those which are required to secure the contact wire to the cantilevers, and those which are required to suspend the contact wire from the messenger wire via the use of in-span droppers. Appendix 7 discusses the design and procurement details of the clamps in this category. All are availabe off-the-shelf from several manufacturers, but for purposes of ensuring material and dimensional control, all items in this category are covered by design drawings. The cost of these items make up 8.2% of the total cost of electrical components and assemblies.

7.4 SECTION INSULATORS AND OVERLAP INSULATORS

The requirement for section insulators and overlap insulators is very much site-specific and is therefore best dealt with on a unit cost basis. Unit costs for section insulators are as low as $2,020 each and for overlap insulators as low as $90.00 each. For the total BCR Tumbler

Ridge Branch Line electrification requirement, the cost of these insulators was less than 2% of the total cost of electrical components and assemblies.

7.5 ELECTRICAL COMPONENTS AND ASSEMBLIES - SUMMARY

The table at the end of Appendix 7 summarizes the cost information on the five segments making up this category or grouping. On the basis of total contract orders, it can be seen that the contact wire and messenger wire requirements make up roughly 40% and 30% of the total respectively. The summary also indicates that variations in offers among suppliers for wire are minimal. See Appendix 8 of this report for further details of this category in the context of the total OCS.

8. CONCLUSION

The components and assemblies for a 50 kV overhead contact system can be designed and specified for an electrified rail line in the Canadian context (such as the BCR Tumbler Ridge Branch Line) in a relatively short period by adaptation of designs which have been tried and proven by the Swedish State Railways under environmental conditions similar to those in Canada.

Further adaptation and improvements to the design (e.g. to enhance standarization, ease of manufacture, etc.) were limited only by the severe time constraints imposed by the schedule not only to design the OCS, but also to implement the design for the BCR Tumbler Ridge Branch Line (which was itself under construction at the same time).

Virtually all materials required for the 50 kV OCS can be manufactured in North America if not in Canada, at a price. For the BCR Tumbler Ridge Branch Line, the following items were purchased off-shore for the reasons indicated:

Cantilever insulators - purchase cost saving
Cantilever tubing - purchase cost and delivery
Catenary clamps - purchase cost and delivery
Special insulators
(section insulators, etc.) - purchase cost saving

The cost of those items purchased off-shore and their percentage of the total OCS material costs is as follows:

Cantilever insulators	$532,311.00	8.33%
Cantilever tubing	23,636.15	0.04
Catenary clamps	177,266.70	2.77
Special insulators	40,674.00	0.06
Total cost of imports	$773,887.85	11.20
Total cost of OCS material	$6,391,415.00	100.00%

The material costs making up the total of $6,391,415 are summarized on the following page. The material has been grouped into three categories and a comparison of any given category versus the total for all three categories produces the following figures from which it is concluded that each category (as defined) represents roughly 1/3 of the material costs for the OCS.

Percentage of Total OCS Material Costs
Based on Track Kilometres Electrified

	High	Low	Average	Contracted
Support Structures	30.91	34.44	33.19	34.12
Mechanical	43.05	32.83	37.83	33.19
Electrical	26.04	32.73	28.98	32.69
Total	100%	100%	100%	100%

Material costs for support structures as designed for the BCR Tumbler Ridge Branch Line are tabulated on page 16. Material costs for the major mechanical assemblies are as shown on page 17. Engineering costs are shown on page 19.

OVERHEAD CONTACT SYSTEM MATERIAL COST SUMMARY

	1	2	3	4	5	6	7	8
Material	High	Low	Average	Selected	Ratio Avg/Sel	Total Order Value	% of Subtotal	% of Total
Support Structures								
Poles	1,465,362	1,139,774	1,332,065	1,141,124	1.00	1,141,124	55.95	
Foundations	939,135	714,794	812,091	717,701	1.00	717,701	35.19	
Portals	159,597	93,500	121,759	93,500	1.93	180,800	8.86	
Subtotal	2,584,094	1,948,068	2,265,915	1,952,325	1.04	2,039,625	100.00	31.91
Mechanical								
Castings, etc.	1,831,293	950,633	1,270,793	950,633	1.10	1,049,149	47.85	
Insulators	1,455,882	621,713	1,008,532	665,958	1.02	679,010	30.97	
Nut and bolts	243,305	138,576	190,940	138,028	1.04	143,028	6.52	
Tubing	110,520	110,520	110,520	110,520	1.00	110,520	5.04	
Tunnel hardware	260,340	153,550	196,921	153,500	.60	92,209	4.21	
Misc. hardware	79,537	79,537	79,537	79,537	1.00	79,537	3.63	
Wire rope and guys	70,933	35,267	49,418	38,872	1.00	38,877	1.78	
Subtotal	4,051,810	2,089,996	2,906,661	2,137,048	1.03	2,192,325	100.00	34.30
Electrical								
Contact wire	945,638	856,680	882,644	877,364	1.00	877,364	40.63	
Messenger wire	805,738	632,200	706,758	632,200	1.00	632,200	29.28	
Ground & feeder wire	291,320	251,187	270,558	251,187	1.00	251,187	11.63	
Misc. wire, etc.	156,438	85,750	111,891	87,075	1.20	104,508	4.84	
Fittings, etc.	294,206	294,206	294,206	294,206	1.00	294,206	13.62	
Subtotal	2,493,340	2,120,023	2,266,057	2,142,032	1.01	2,159,465	100.00	33.79
GRAND TOTAL	9,129,244	6,158,087	7,438,633	6,231,405	1.03	6,391,415		100.00

MATERIAL COST SUMMARY - SUPPORT STRUCTURES

Pole & Foundation	High	Low	Average	Contracted
C130 x 10, Type I	879	640	768	641
C130 x 13, Type I	955	714	843	715
C150 x 16, Type I	1,026	790	910	791
C250 x 30, Type I	1,558	1,201	1,348	1,201
C130 x 10, Type II	1,188	693	884	764
C130 x 13, Type II	1,264	767	959	838
C150 x 16, Type II	1,335	843	1,026	914
C250 x 30, Type II	1,950	1,251	1,496	1,359
C130 x 10, Type III	661	479	570	481
C130 x 13, Type III	737	553	645	555
C150 x 16, Type III	808	629	712	631
C250 x 30, Type III	1,340	1,041	1,149	1,042
Portals - 17 metre	3,275	1,910	2,620	2,090
- 18 metre	3,550	2,025	2,735	2,275
- 19 metre	3,840	2,135	2,860	2,460

Assembly Description	High	Low	Average	Contracted
Single cantilever	822.75	284.90	448.69	298.77
Single cantilever, inner curve	878.40	313.79	487.31	327.66
Single cantilever, mid-point anchor	872.37	310.66	483.13	324.53
Tunnel catenary support assembly, CS1	740.69	402.46	534.40	402.46
Tunnel catenary support assembly, CS2	979.29	543.14	714.87	543.14
Tunnel catenary support assembly, CS3	1,118.12	625.00	819.89	625.00
Tunnel catenary support assembly, CS4	758.99	413.25	548.24	413.25
Tunnel catenary support assembly, CS5	805.84	441.14	584.02	441.14
Tunnel catenary support assembly, CS6	821.74	450.25	595.71	450.25
Tunnel catenary support assembly, CS7	1,206.21	676.94	886.52	676.94
Parsnip River Bridge cantilever Type A	800.09	273.14	432.97	287.01
Parsnip River Bridge cantilever Type B	807.22	276.84	437.91	290.65
Single cantilever-portal center track	1,349.41	558.20	814.03	572.07
Double cantilever-portal center track	2,759.41	1,148.04	1,670.36	1,175.78
Double cantilever-electric section	1,745.88	621.91	967.04	649.65
Double cantilever-switches	1,636.51	565.14	891.15	592.88
Double cantilever-overlaps	1,629.70	561.60	886.42	589.34
Weight tensioning-single track-9.8 kN	4,037.75	2,115.71	2,235.27	2,128.16
Weight tensioning-portal-9.8 kN	4,107.26	2,155.98	2,874.77	2,168.43
Mid-point anchors	474.31	370.28	416.97	370.28
Feeder wire support	187.41	140.16	157.82	140.16
Ground wire support	38.60	23.38	29.47	23.38
With extension bracket	51.11	29.87	38.15	29.87

Material costs for electrical components and assemblies are best stated in terms of cost per track kilometres.

Costs per kilometre of electrified track, based on the design of the OCS of the BCR Tumbler Ridge Branch Line are shown on the following page.

	High	Low	Average	Contracted
Contact wire	5,630	5,100	5,255	5,225
Messenger wire[1]	4,030	3,160	3,535	3,160
Earth & feeder wire2	1,225	1,055	1,140	1,055
Misc. wire[3]	710	370	485	375

[1] Earth and feeder wire in tunnels are the same as the messenger wire.

[2] Earth and feeder wires are the same size.

[3] The miscellaneous wire includes the wire requirements for jumpers, potential equalizers, in-span droppers, and earth wire-to-rail connections.

In-span electrical components such as wire fittings, clamps, droppers, and insulators amount to approximately 4 to 5% of the total OCS material costs. The following costs per track kilometre are based on the contracted costs for this type of material as used on the BCR Tumbler Ridge Branch Line.

Wire fittings	$ 240.00
Wire clamps	870.00
Droppers	215.00
Insulators	250.00
Total	$1,575.00/kilometre

For gross estimating purposes, the following cost variations per kilometre of electrified track can be used:

Category	High	Low	Average	Contracted
Support Structures	$17,761	$13,389	$15,574	$13,418
Mechanical	24,742	12,762	17,749	13,050
Electrical	14,962	12,721	13,598	12,854
TOTAL	$57,465	$38,872	$46,921	$39,322

OCS ENGINEERING COSTS

Engineering was progressed through three stages - conceptual design, detailed design and implementation.

This permitted an evaluation of feasibility while at the same time permitting some of the work such as the installation of rock bolts for tunnel OCS supports to be made. The implementation stage, while not being construction management, provided engineering assistance and monitoring as required.

Costs incurred were:

Conceptual Design	-	$216,420
Detailed Design	-	641,955
OCS Implementation	-	529,135
TOTAL		$1,387,510

These figures do not include foundation engineering or bridge structure costs which were done outside the scope of this report.

Furthermore, costs have not been reduced to a per kilometre basis because they cover such items as pole, portal and cantilever design which would be the same for either 100 or 1,000 kilometres of line.

APPENDIX 1

CONCEPTUAL DESIGN REPORT

BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE ELECTRIFICATION

CONCEPTUAL DESIGN REPORT

Montreal, Canada
March 1983

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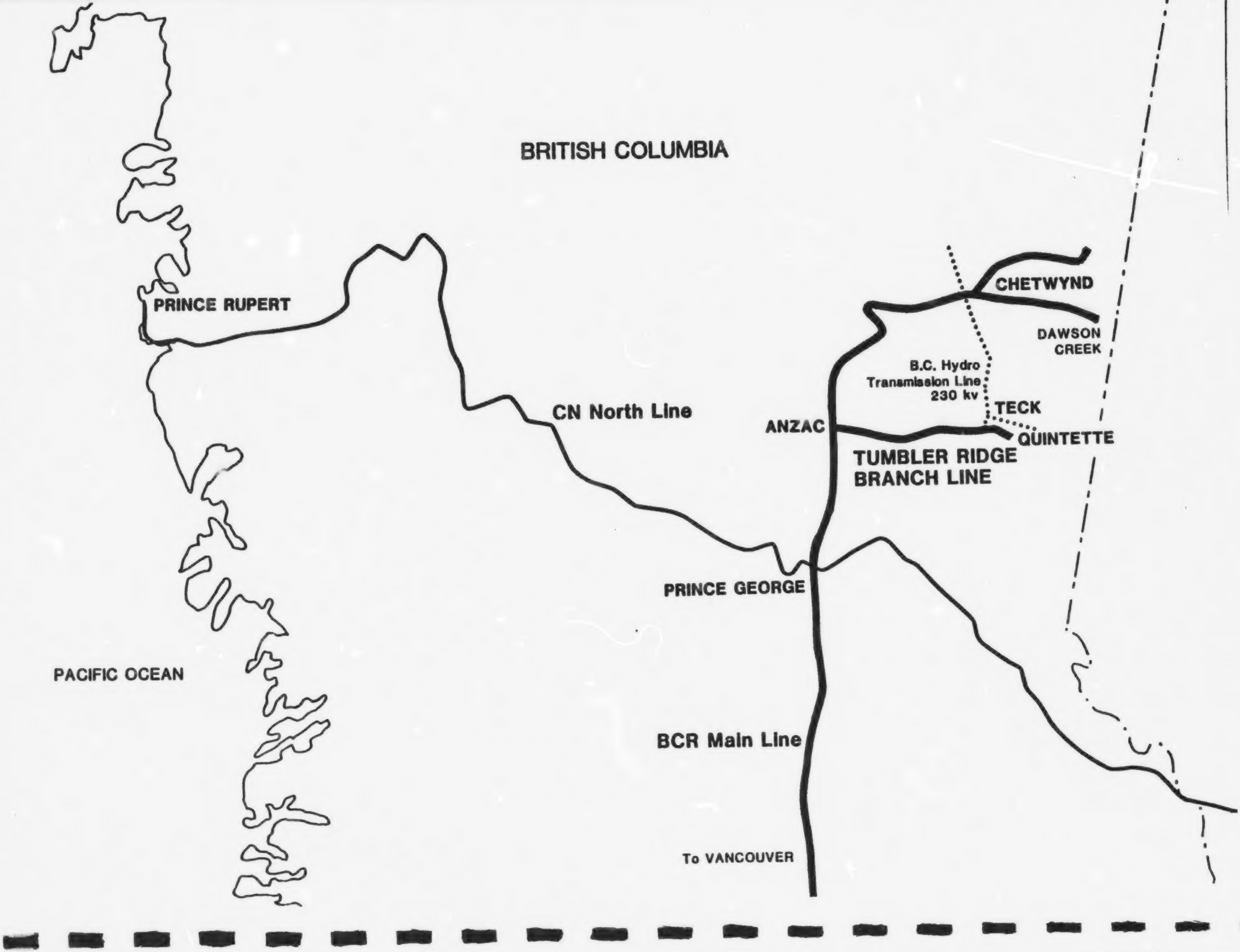

BRITISH COLUMBIA
PRINCE RUPERT
CHETWYND
DAWSON CREEK
B.C. Hydro Transmission Line 230 kv
TECK
QUINTETTE
CN North Line
ANZAC
TUMBLER RIDGE BRANCH LINE
PRINCE GEORGE
PACIFIC OCEAN
BCR Main Line
To VANCOUVER

CONCEPTUAL DESIGN REPORT

1. INTRODUCTION

1.1 BACKGROUND

Following extensive study of the feasibility of electrifying the Tumbler Ridge Branch Line of the British Columbia Railway (see TDC report TP 3619E) and various alternative unit train operations on such an electrified branch line (see TDC report TP 3691E) a decision was made by BCR to electrify the entire Tumbler Ridge Branch Line from km 0 to km 130 including both load-out loops at Teck and Quintette. (Appendix 1 is a brief resumé of branch line characteristics).

1.2 PURPOSE

The purpose of this report is to document the results of the conceptual design phase which was conducted prior to any detailed design phase(s).

1.3 PLANNED RAILWAY OPERATIONS

With the signing of the Coal Haulage Agreements between CN, Teck and Quintette on April 2, 1982, designated tonnage to be shipped over the Tumbler Ridge Branch Line was agreed to be approximately 8.5 million metric tonnes of coal per annum with a possible 9.35 million metric tonne maximum tonnage permissible in any coal year, a 10% overage.

Given the maximum amount of product to be moved, customer delivery needs, BCR and CN operational requirements, the rail operational characteristics of the system can be defined. With the rail operations established and physical characteristics of the terrain given, the electrical characteristics of the system may be designed to permit the contemplated operation.

1.4 THE STUDY APPROACH

Having defined overall system characteristics, electrification requirements were further subdivided into a series of identifiable subsystems, each subsystem in turn into a series of engineering tasks.

There are three major electrical subsystems; the electrical prime movers (locomotives), the overhead contact system (OCS) and lastly, the power supply and distribution system.

The conceptual design phase was restricted to the characteristics of the latter two subsystems and their design parameters, on the basis of assumed or given characteristics of the electric locomotives.

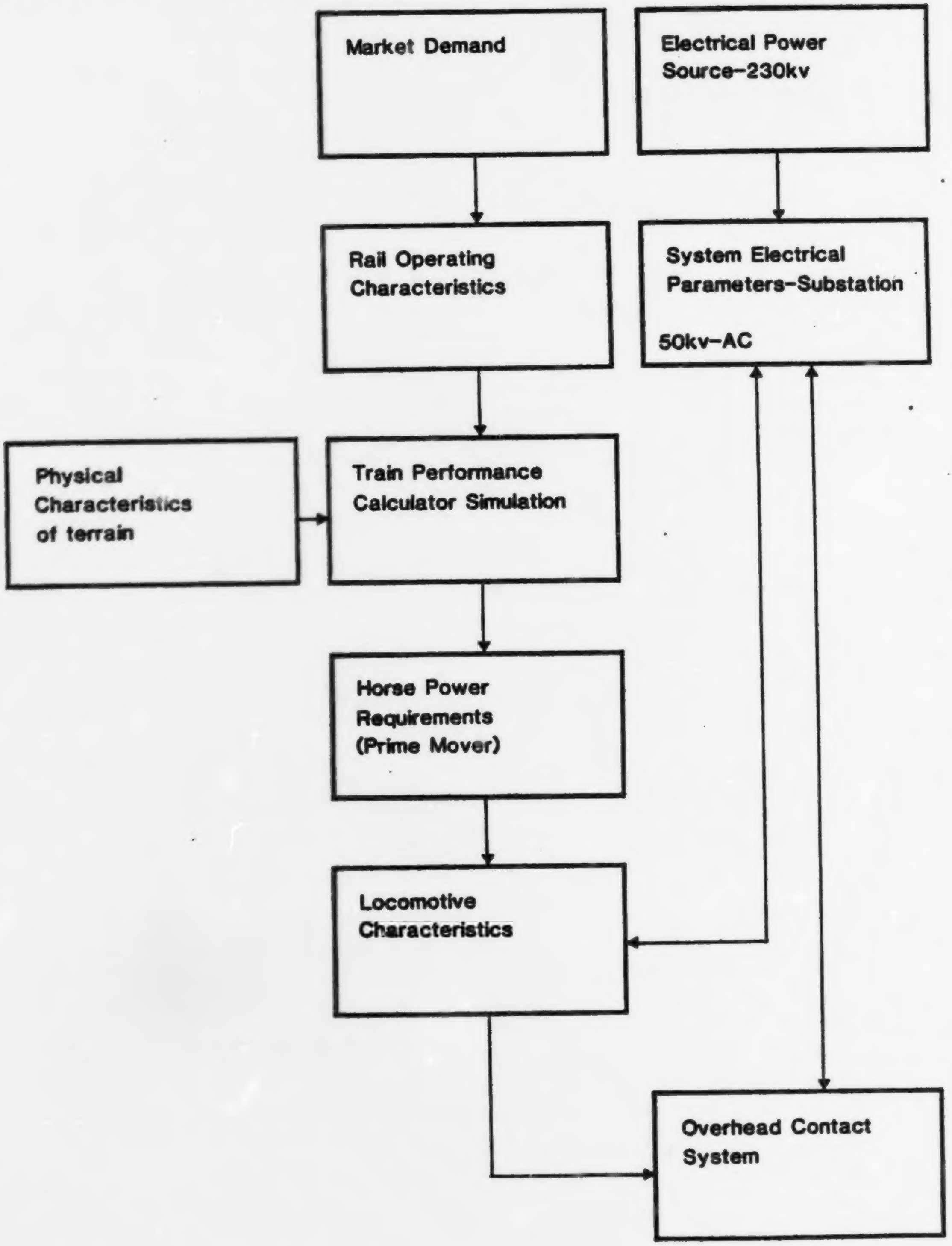
2. DESCRIPTION OF TUMBLER RIDGE OPERATIONAL REQUIREMENTS

2.1 INTRODUCTION

Various combinations of train operations were simulated by means of a Train Performance Calculator (TPC) computer program. In addition to proving that the operational design parameters as dictated by contractual requirements could be achieved, the train performance calculator permitted the definition of system requirements.

Substation characteristics, overhead contact system requirements, and line voltage drop calculations permitted further refinement of the power supply system and power factor correction capacitor requirements. Figure 2.1 is a simplified schematic of the logic of the final decision and design process.

Figure 2.1
SYSTEM DESIGN PROCESS


Market Demand
Electrical Power Source-230kv
Rail Operating Characteristics
System Electrical Parameters-Substation 50kv-AC
Physical Characteristics of terrain
Train Performance Calculator Simulation
Horse Power Requirements (Prime Mover)
Locomotive Characteristics
Overhead Contact System

Of particular interest in Figure 2.1 is the design loop encompassing locomotive characteristics, overhead contact system and substation/ power distribution system.

The necessity of building this feedback process results from the fact that the locomotives being electrical in nature require a minimum voltage at the pantograph to operate properly. As the locomotives move along the track pulling their loaded and empty trains, they in effect, along with the overhead contact system define a continually changing electrical circuit. As the characteristics of this circuit change, that is as the distance of the trains from the voltage source changes, the voltage drops in various parts of the electrical circuit, i.e. the track, the overhead contact system and the locomotives, continually change. A feedback process is required to verify that under the operating conditions, sufficient voltage is always maintained at the locomotive.

2.2 PROPOSED OPERATIONS

Basic operational design parameters began with the premise that 10.5 million tons of coal per year would be shipped down the Tumbler Ridge Branch Line for export at Prince Rupert. Assuming 350 days per year of actual train operation yields a 30,000 ton daily requirement to move down the line.

The 30,000 ton per day requirement could be met most conveniently by using three 10,000 net ton trains every 24 hour period.

2.3 TRAIN PERFORMANCE CALCULATOR

Initial TPC runs (Appendix 2) suggested that with the requirements to run 98 car trains plus a caboose and maintain a maximum track speed of 35 mph in the loaded direction and 45 mph in the empty direction, a peak horsepower requirement in the order of 21,000 hp at the traction motors would be required. In the empty direction (i.e. backhaul), power requirements could be significantly reduced.

2.4 CATENARY VOLTAGE AND POWER FEED

It was recognized from the start of the feasibility studies that for a single catenary section 130 km long fed from one end only, for the given train and track characteristics, the catenary voltage drop becomes the principal criterion for the electrical design of the catenary system. Indeed it was basically the voltage regulation on the catenary which led to the choice of the 50 kV catenary system voltage. (Discussed in Section 3).

The minimum pantograph voltage as specified by the locomotive supplier was 38 kV for full tractive effort down to 35 kV at reduced tractive effort at which point the locomotive auxiliaries shut down.

The voltage drop is a function of the current in the catenary, the distance between the substation, the instantaneous position of the train(s), and the per km impedance of the catenary system.

It was shown in the feasibility study that with the catenary fed from the Tumbler Ridge end, and using a contact system consisting of a 100 mm^2 copper contact and 50 mm^2 bronze messenger wire, a 50 kV catenary system supplied from one end, a 90 km long catenary can handle a single loaded train drawing 15 MW at the pantograph.

After examining the above results, the question was raised whether the branch line could be electrified at 25 kV rather than 50 kV in order to take advantage of more easily available 25 kV locomotives.

The subsidiary study performed to answer this question demonstrated that the 25 kV system providing the same performance as the 50 kV system would require at least 2-230/50 kV substations, one at Tumbler Ridge and one around km 55 with the km 55 substation fed from a single phase 230 kV feeder to be run from Tumbler Ridge along the railway. The 25 power supply system was shown to be $4.5 million more expensive than the 50 kV system and was discarded.

After the first phase of the feasibility study, it was decided that the electrification of the branch line be extended to km 0 at Anzac and that the system should be capable of serving a realistic train schedule involving one loaded and one empty train travelling in the branch line. This required the reduction of the impedance of the initially envisaged 50 kV catenary system to stay within the specified voltage limits under all realistic operating conditions.

This reduction was achieved by two measures. Firstly, impedance of the catenary was reduced by changing the cross section of the messenger wire from 50 mm^2 bronze to 70 mm^2 copper and by adding a separate parallel connected 107 mm^2 ACSR feeder wire run along the catenary poles. Secondly, it was decided to insert a 15 ohm series capacitor in the catenary system between the Wolverine and the Table Tunnels in order to reduce the effective impedance of the system between the series capacitor station and Anzac. The combination of the above design features led to a system which would allow any envisaged realistic train schedule in the branch line without violating the lower limit of the permissible pantograph voltage. (See Appendix 3, Voltage Profile).

3. POWER AVAILABILITY

3.1 FACTORS FAVOURING 50 KV

The choice of 50 kV as an economical alternative to the more conventional 25 kV, resulted from an analysis which demonstrated that catenary feeding sections could be increased to the extent that the entire line could be served through one substation. Considering the line was in a relatively isolated area, that it could be designed to accommodate the required overhead clearances necessitated by 50 kV, and that power at 50 kV was readily available (B.C. Hydro's 230 kV power transmission to the mine-site was within 2 km of the branch line), the main opposing factors to the choice of 50 kv were cleared away.

3.2 SUBSTATION LOCATION

Two possibilities were investigated. The first, locating the substation at the Branch Line and bringing the 230 kV line from the BC Hydro substation to the BCR substation; and the second alternative was to locate the BCR substation adjacent of the B.C. Hydro substation feeding the two mine sites.

Although the tap from the B.C. Hydro substation to the BCR substation would have been two kilometres long and the most efficient from a power transmission viewpoint, a decision was made to build the BCR substation adjacent to the B.C. Hydro substation. This decision rested on the fact that both power stations would be at a common site with common access facilities. In addition, it was felt that a circuit breaker could be saved in a design process by having the two substations juxtaposed. With the choice of the second alternative, the light pole line from the track to the 50 kV source was required.

3.3 SUBSTATION DESIGN

The BCR Tumbler Ridge 230/50 kV railway substation is located immediately adjacent to the BC Hydro 230 kV substation as explained in Section 3.2 and is fed from a short extension of the BC Hydro 230 kV bus. There is a 230 kV entrance circuit breaker in the BCR substation which was required due to protection coordination and interfacing problems with BC Hydro.

Two 230/50 kV single phase transformers, each rated at 33 MVA with forced air cooling, will be installed in the substation. The two transformers will normally operate in parallel, but they are rated on the basis of 100% standby; i.e. one transformer can supply the maximum railway demand envisaged. The transformers are connected phase to phase on the 230 kV side and phase to ground on the 50 kV side. The transformers have no on-load voltage regulators, only off load taps, as no substantial daily variation in the 230 kV voltage is expected and the selected low transformer reactance enables the maintenance of a reasonably steady voltage on the 50 kV bus.

On the 50 kV side, the transformers feed a 50 kV bus. There are three 50 kV feeder breaker positions on this 50 kV bus. One is used for the normal supply of the catenary over the 2 km, 50 kV pole line described in Section 3.2. A second breaker is installed to serve as standby to the normal catenary feeder breaker. The third feeder breaker is used to connect a 6.5 MVAR shunt capacitor and harmonic filter combination.

The rating of the shunt capacitor-filter unit was selected on the basis of the analysis of the TPC runs giving an average reactive power demand of about 7 MVAR at the substation 50 kV bus. A reactor connected in series with the capacitor bank makes the unit function as a third harmonic filter as well, absorbing a large portion of the third harmonic (180 Hz) current generated by the electric locomotives.

The catenary feeder circuit breakers will be equipped with an automatic reclosing relay to enable one reclosure after a fault initiated trip-out of the catenary. This scheme improves service continuity as the majority of faults are of a transient nature and disappear after a brief de-energization of the catenary.

4. OVERHEAD CONTACT SYSTEM

4.1 INTRODUCTION

In concept, the overhead contact system was based on the designs tried and proven by the Swedish State Railways in climatic conditions very similar to those in northeastern British Columbia. During the subsequent detailed design phase, the Swedish designs would be adapted wherever possible to North American standards and to the specific requirements of the Tumbler Ridge Branch Line.

The overhead contact system is composed of two major subsystems: the mechanical subsystem - i.e. poles, cantilevers, tensioning devices; and the electrical subsystem consisting of the actual contact wire, the ground wire which is electrically connected to the track and the messenger-dropper wire system which maintains the contact wire at the correct height above the rails and forms part of the electrical circuitry. Figure 4.1 illustrates these components.

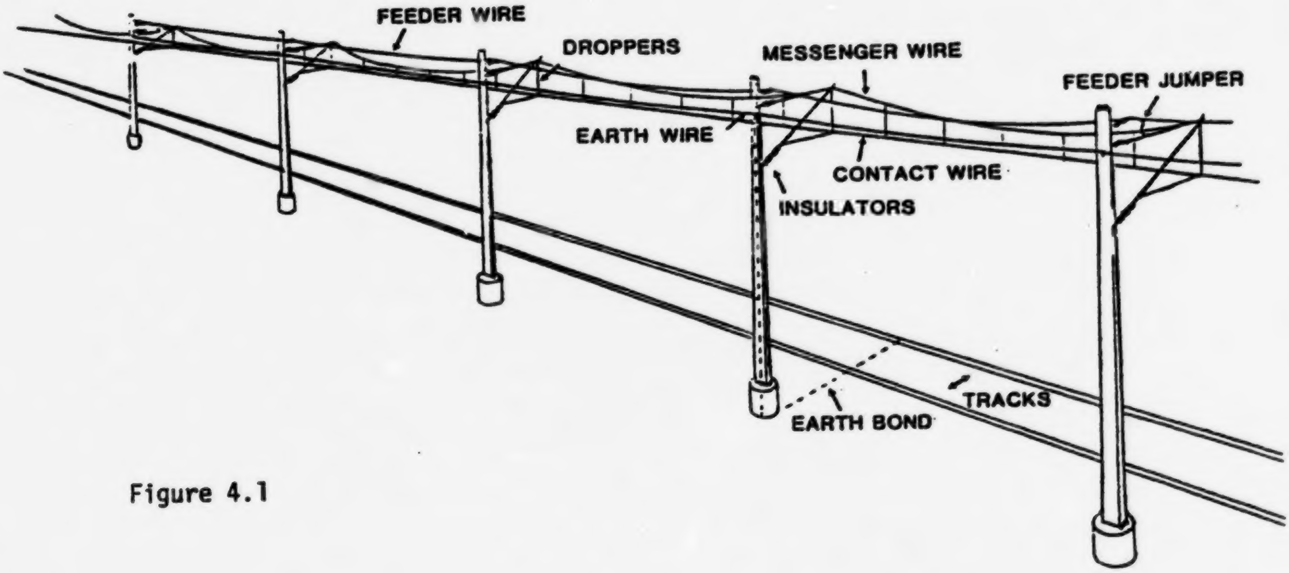


Figure 4.1

For design purposes, maximum train consist was assumed to require a maximum of four locomotives (four pantographs) with the distance of 51.4 to 74.6 metres between the outer pantographs. The line was assumed to have a total length of approximately 130 kilometres; the curve radius varying from 291 metres to 3,500 metres and a maximum gradient of 1.5%.

The speed limit was assumed to be 65 km/h (40 mph); however, the overhead catenary system was designed for a maximum speed of 80 km/h when power requirements necessitated the simultaneous use of four pantographs. With only one pantograph in use, a design speed limit of approx. 120 km/h (75 mph) is possible due to reduced pertubation effects of the single pantograph.

Design considerations also accounted for current collection deterioration under severe ice loading conditions.

4.2 ELECTRICAL SUBSYSTEM

4.2.1 Contact Wire Height

Normal contact wire height above top of rail (TOR) is 6,500 mm. Because of physical restrictions, contact wire height is reduced to 6,000 mm in all tunnels and on the Parsnip River Bridge.

On the BCR main line, from Tacheeda siding to Tumbler Ridge Branch line junction, km 0, contact wire height is to be 7,000 mm.

4.2.2 Pole Distance and Span Length

The pole distance from track center line to pole center line is:

- normally 3,500 mm
- minimum (on tangent track) 2,440 mm (to nearest face of the pole)

On curved track, this minimum is increased.

The maximum span length will be 70 metres. On curved track, the span length will be reduced.

4.2.3 Poles

Pole designs initially investigated consisted of wood poles (too flexible, requiring guy wiring), poles fabricated from part-worn rail (too heavy, unsightly, costly), and concrete poles (too heavy, brittle, costly).

Final design consisted of steel poles of varying length and cross-sectional areas based on the designs used by the Swedish State Railways.

4.2.4 Electrical Characteristics and Clearances

4.2.4.1 Overhead line voltages

Nominal: 50 kV
Minimum: 35 kV
Maximum in normal operation: 55 kV

4.2.4.2 Frequency: 60 Hz

4.2.4.3 Clearances

The clearances incorporated in the design comply with AAR/AREA recommendations. Because of the 900-1,200 meter average height above sea level, a correction factor of 1.02 has been incorporated in design factors.

Normal electrical clearances:

- passing 414.5 mm (16" x 1.02) - under train movement
- static 544.1 mm (21" x 1.02) - no pantograph pressure

Absolute minimum electrical clearances:

- passing 310.9 mm (12" x 1.02)
- static 414.5 mm (16" x 1.02)

The aforementioned values have been incorporated and are valid between overhead contact system and earthed structures (tunnels, bridges, etc.) and between contact wire and rolling stock.

4.2.5 Climatic Conditions

The overhead contact system has been designed and planned according to CSA Standard C22.3 No. 1-M1979 "Overhead systems".

The overhead contact system (including poles and portals) has been designed to withstand additional loads caused by hoar frost, fog frost, ice, snow and wind in compliance with Class A (Swedish norms) normally used on lines which are part of a national distribution electrical transmission grid.

4.2.5.1 Ice load in the presence of wind

The load is assumed to occur as a cylindrical coating around the conductor with a Class A coating thickness (Canadian norm of 12.7 mm).

4.2.5.2 Wind load

The wind pressure is assumed to be 1.2 kN per m^2 of flat surface struck by the wind in the direction perpendicular to the surface. This wind pressure was assumed after comparing Canadian and Swedish norms for this type of overhead systems.

4.2.5.3 Temperature (Overhead Contact System)

4.2.5.3.1 Minimum temperature

The minimum contact wire temperature is assumed to be $-50^{o}C$.

4.2.5.3.2 Maximum temperature

a) The maximum temperature of the conductors will be $50^{o}C$, ambient temperature at no wind plus temperature rise caused by operating current values;

4.2.6. Other Design Considerations

The conceptual design phase incorporated basic electrical safety considerations. Complete safety engineering is considered integral to the detailed design phase.

Electrical safety considerations at the conceptual phase concerned personnel responsible for the maintenance of track and the overhead contact system, as well as the general public.

As far as the general public is concerned, where the overhead contact system can be approached, for example, level crossings or other roads parallel or close to the railway, suitable signs warning of the high voltage catenary will be erected. In addition, protective gates will be erected at road crossings and pedestrian crossings. To assure adequate vertical clearance between vehicles and the overhead contact system, portal structures will be constructed with prominently displayed signs indicating maximum clearance.

Within the right-of-way, major safety concerns will be the adequate grounding of the catenary poles, switches and signalling equipment, and maintenance tools and equipment.

The structures adjacent to the line such as buildings, fences, pipe lines etc. will also require grounding and/or electrical insulation so as to prevent significant potential gradients from developing.

In addition to the foregoing, it is anticipated suitably prepared standard operating procedures will provide adequate guidance for concerned operating and non-operating employees.

4.3 MECHANICAL SUBSYSTEMS

4.3.1 Suspension System

The contact wire is maintained at the correct height above the track through the use of a presagged catenary system. These wires (messenger and contact wire) are maintained at constant tension over the entire length of the line through the use of an automatic weight tensioning system which permits compensation for temperature variations. (Long tunnel sections which do not experience wide temperature fluctuations are installed as a fixed termination system; see paragraph 4.3.4).

4.3.2 Catenary Components

Component	Material
a) Contact wire	107 mm^2 hard-drawn copper
b) Messenger wire	70 mm^2 hard-drawn copper, stranded
c) Earth wire	4/0, (125 mm^2) ACSR - Stranded Aluminum Conductor, Steel Reinforced
d) Feeder wire	4/0, (125 mm^2) ACSR
e) Dropper wire	5 mm^2 hard drawn, copper wire

The linear impedance of this OCS electrical system was determined to be Z/km = 0.145 + j0.48 ohms/km.

4.3.3 Contact Wire Stagger

To equalize wear on the locomotive current collection system, the contact wire has been staggered (zigzag) about the center line of the track. This stagger reduces pantograph wear and assures that the contact surfaces wear uniformly.

On tangent track the stagger about the center line will be 400 mm, while on curved track the stagger will be a function of the radius of curvature varying from 250 mm on 0.5^o curves up to 450 mm on 1.5^o curves.

4.3.4 Tunnel Sections

Over 10% of the Tumbler Ridge Branch Line will be tunnel. IECO (International Engineering Company) of San Francisco who have significant tunnel electrification experience, was selected to provide a conceptual design and detailed design of these critical Branch Line sections.

A fixed termination design will be used throughout the long tunnel as compared to the automatic tension system used externally. The same overhead contact wire and messenger wire will be used in the tunnels as externally; however, the earth return wire will not be ACSR as used externally, but rather will be the same as the copper messenger wire. It was felt that the steel core of the ACSR would be subject to corrosion problems due to continuous moisture in the tunnels.

The parallel feeder wire which simply provides an additional current carrying capability decreasing linear impedance of the overhead contact system will only be used in the tangent sections of the tunnel and not in those sections where the automatic tensioning and fixed termination systems overlap. These transitional areas would have presented additional mechanical design problems whose cost would not be worth the improvement in any, in electrical characteristics.

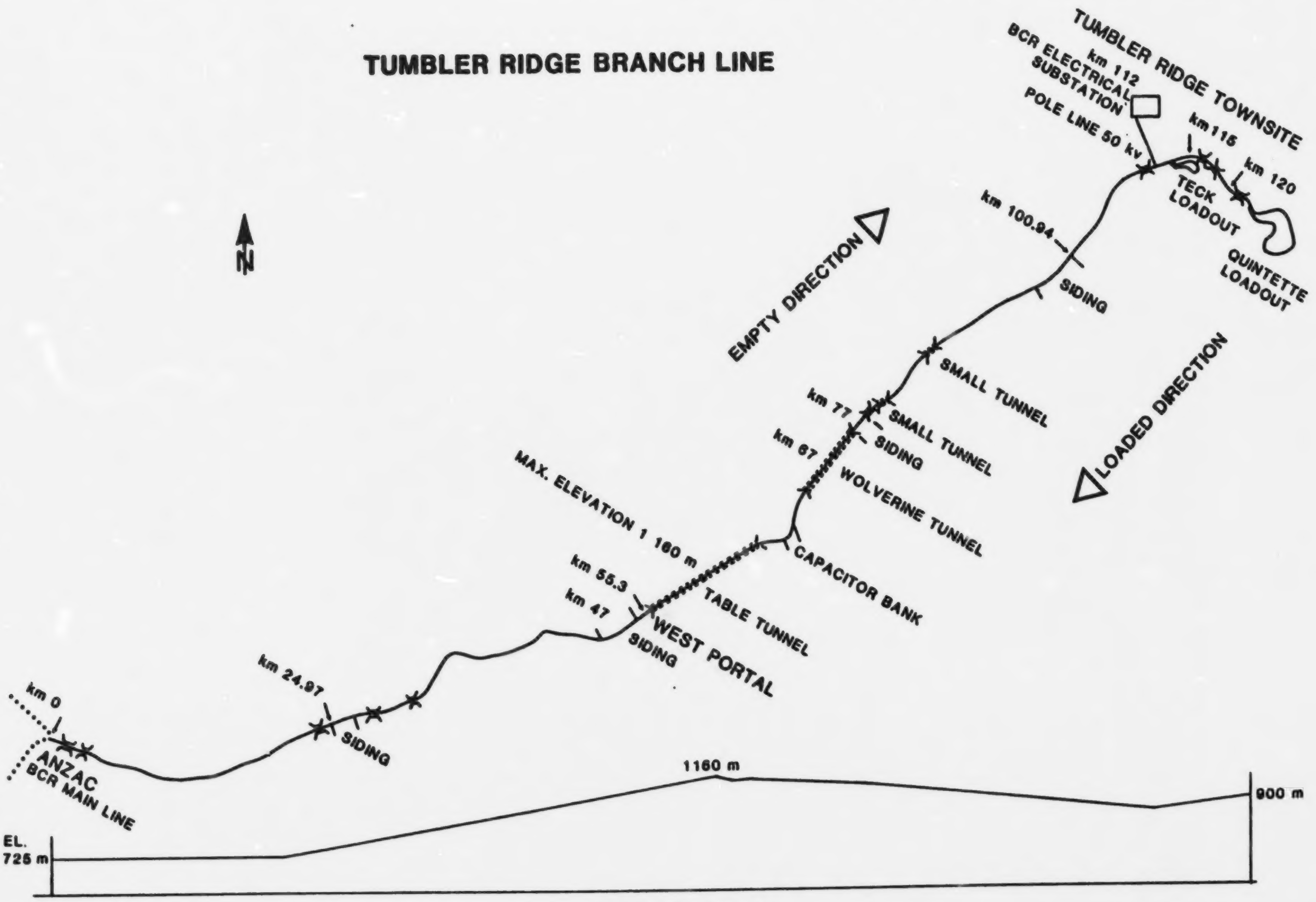
Supports will be installed every 50 metres to support the messenger and contact wires. At overlaps the supports will be spaced every 25 metres.

Sections of approximately two kilometres in length will be used within the long tunnels as opposed to approximately 1,200 metres employed externally. A detailed report on the conceptual design of the overhead contact system in the long tunnels is contained in IECO detailed design reports.

APPENDIX 1

DESCRIPTION OF BRANCH LINE

TUMBLER RIDGE BRANCH LINE


N
TUMBLER RIDGE TOWNSITE
km 112
BCR ELECTRICAL SUBSTATION
POLE LINE 50 kv
km115
km 120
TECK LOADOUT
QUINTETTE LOADOUT
km 100.94
SIDING
EMPTY DIRECTION
LOADED DIRECTION
SMALL TUNNEL
km 77
SMALL TUNNEL
SIDING
km 67
WOLVERINE TUNNEL
CAPACITOR BANK
MAX. ELEVATION 1 160 m
km 55.3
TABLE TUNNEL
km 47
WEST PORTAL
SIDING
km 24.97
SIDING
km 0
ANZAC
BCR MAIN LINE
EL. 725 m
1160 m
900 m

PROFILE (not to scale)

APPENDIX 1

A1. DESCRIPTION OF BRANCH LINE

A1.1 GENERAL DESIGN STANDARDS

The proposed new rail line will be constructed between Anzac and Tumbler Ridge, British Columbia, a distance of approximately 120 km. In addition, there will be a loop track to service the Teck Corporation mine and a spur and loading loop of approximately 12 km to serve the Quintette Coal Limited mine.

The maximum curvature on the line is 8^0 except in the loop tracks where a maximum of 9 $1/2^0$ will be permitted. The maximum gradient in the loaded direction will be 1.2% compensated and 1.5% compensated in the empty haul direction.

The track will be built with an eight metre wide top of subgrade and a minimum clearance through the tunnels of 2.440 metres from centre line of track to tunnel walls on tangent track and 2.740 metres on curved track. (Slightly larger than standard BCR Load Clearance Gauge).

A1.2 DESCRIPTION OF BRANCH LINE

Starting from Anzac, the Tumbler Ridge Branch Line will be constructed over relatively level ground with maximum gradient of 1.5% in the empty direction (direction Tumbler Ridge) and 1.2% in the loaded direction (direction Anzac) for a distance of approximately 28 km. The maximum degree of curvature between Anzac and km 28 is 4^0.

Between km 28 and km 55.2, the line will rise up to the maximum elevation of the line. The gradient in the empty direction is basically 1.5% throughout and all downgrade in the loaded direction. The maximum degree of curvature is 6^0.

A continuous tunnel (Table Tunnel) will exist between km 55.2 and km 64.3. The line is tangent throughout the tunnel except for small portions of curved track at the western and eastern portals (4^o and 2^o respectively).

Within the tunnel, the maximum gradient is 0.10% in the empty direction up to a maximum elevation of 1,160 metres at km 58.9. Beyond 58.9, the gradient is .28% in the loaded direction.

Between km 64.3 and km 70.7 the branch line drops down to the Sukunka River Valley and rises again to the west portal of another long tunnel (Wolverine Tunnel). Within this valley, the maximum gradient in the loaded direction will be 1.2% and .81% in the empty direction; a maximum curvature of 8^o will be encountered at the western portal to this tunnel.

A continuous straight tunnel will exist between km 70.7 and km 76.7. The gradient throughout the tunnel will be .77% in the loaded direction.

From km 76.7 and km 99 the rail line will have a continuous gradient of 1.2% in the loaded direction with maximum curvature of 6^o.

From km 99 to km 109 the line gently rises and falls and between km 109 and km 114 and km 117 and km 118 a gradient of 1.2% in the loaded direction will exist. Beyond km 118 to the end of steel, the gradient will be a maximum of 1.5% in the empty direction with a maximum curvature of 6^o.

The Tumbler Ridge town site will be in the vicinity of km 121; the Teck Corporation load-out will be near km 115 and the Quintette load-out near km 134.

A1.3 SIDINGS AND LOOP TRACKS AND WYES

It is proposed to install sidings and 0.8 km of back track at the following points:

kilometre 25 - 28
kilometre 47 - 50

kilometre 77 - 80
kilometre 98 -101

A loop track, capable of holding one loaded train and one empty train, will be constructed in the vicinity of km 115 for Teck Corporation (Bullmoose Load-out Loop).

A loop track at the end of steel km 134 will be constructed to handle Quintette trains (Quintette Load-out Loop).

A wye, for turning locomotives, cars and snow plows, will be constructed at the siding at km 100 and a second wye is proposed for future construction at km 1.

A1.4 BRIDGE DESIGN

All bridges to be constructed between km 25 and km 120 will be deck truss type. One through-truss bridge will be constructed near km 3, over the Parsnip River.

APPENDIX 2

TRAIN PERFORMANCE CALCULATOR COMPUTER RUNS

SUMMARY OF TPC RUNS

Run Description	HP Limit	Max HP Demand (at Rail)	Avg. HP Demand (at Rail)	Speed Limit (mph)	Trip Time (HR:Min)	Avg. Velocity (mph)	Min. Voltage (kV)	Max Power Demand (KVA)
1) Loaded Train Only 4 locomotives	15,000	15,118 @ 1 min	7,623	35.0	3:20	25	42.6	22,959
2) Loaded Train Only 4 locomotives	21,864	20,858 @ 8 min	8,821	35.0	2:54	28.9	39.1	26,682
3) Empty Train Only 4 locomotive	15,000	11,038 @ 4 min	3,294	45.0	3:27	24.2	46.4	9,847
4) Empty Train Only 4 locomotive	21,864	15,344 @ 3 min	5,037	45.0	2:25	34.5	43.2	16,737
5) Loaded Train 4 locomotive and Empty Train (4 locomotives) meet @ km 25 leaves 2:12 min after Loaded Train.	15,000 15,000	15,118 11,038	7,623 3,294	35.0 45.0	3:20 5:59 (25 min siding time)	25.0 24.2	37.6	22,960
6) Loaded Train & Empty Train meet @ km 25 Empty Train leaves 1:49 min. after Loaded Train	21,864 21,864	20,858 15,344	8,821 5,037	35.0 45.0	2:54 4:43 (30 min siding time.)	28.9 34.5	39.1 39.1	26,682 26,682

SUMMARY OF TPC RUNS

Run Description	HP Limit	Max HP Demand (at Rail)	Avg. HP Demand (at Rail)	Speed Limit (mph)	Trip Time (HR:Min)	Avg. Velocity (mph)	Min. Voltage (kV)	Max Power Demand (KVA)
7) Loaded Train	16,000	15,118	7,623	35.0	3:20	25.1	37.0	22,960
Empty Train meet @ km 25 Empty Train leaves 2:12 min after Loaded Train	21,864	15,340	4,653	45.0 (20 mph between km 29 & 39)	5:15 (26 min siding time)	32.0		
8) Loaded Train	16,000	15,118	7,623	35.0	3:20	25.1	37.2	30,899
Empty Train meet @ km 48 Empty Train leaves 1:20 min after Loaded Train	21,864	15,344	4,752	45.0 (30 mph between km 0 & 13)	4:22 (31 min siding time)	33.1		
9) Loaded Train	16,000	15,118	7,623	35.0	3:20	25.1	37.5	32,025
Empty Train meet @ km 48 Empty Train leaves 55 min. after Loaded Train	16,000	11,038	3,294	45.0	4:56 (34 min siding time)	24.2		
10) Loaded Train	16,000	15,118	7,623	35.0	3:20	25.1	42.2	35,696
Empty Train meet @ km 78 Empty Train leaves 2 min after Loaded Train	21,864	15,344	5,037	45.0	2:51 (26 min siding time)	34.5		

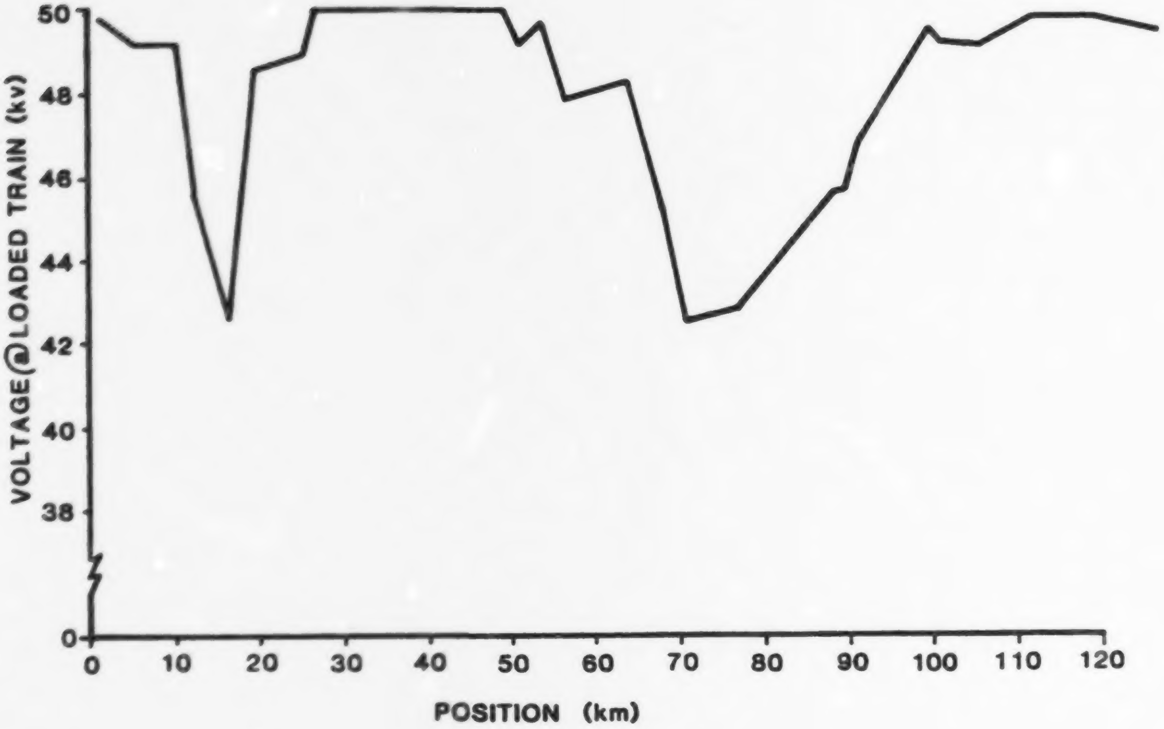
SUMMARY OF TPC RUNS

Run Description	HP Limit	Max HP Demand (at Rail)	Avg. HP Demand (at Rail)	Speed Limit (mph)	Trip Time (HR:Min)	Avg. Velocity (mph)	Min. Voltage (kV)	Max Power Demand (KVA)
11) Loaded Train	21,864	20,858	8,821	35.0	3:04	28.0	39.1	37,713
Empty Train meet @ km 78 Loaded Train leaves 10 min after Empty Train	21,864	15,344	5,037	45.0	2:53 (28 min. siding time)	34.5		
12) Loaded Train	16,000	15,118	7,623	35.0	4:07	25.0	42.2	27,030
Empty Train meet @ km 78 Loaded Train leaves 47 min after Empty Train	16,000	11,038	3,294	45.0	3:48 (21 min. siding time)	24.2		
13) Loaded Train	16,000	15,118	7,623	35.0	5:34	25.0	42.6	32,635
Empty Train meet @ km 100 Loaded Train leaves 2:14 min after Empty Train	16,000	11,038	3,294	45.0	3:58 (31 min. siding time)	24.2		
14) Loaded Train meet at km 100 Loaded Train leaves 1:08 min after Empty Train	21,864	15,344	5,037	45.0	3:00 (35 min. siding time)	34.5		
15) Loaded Train	16,000	15,118	7,623	35.0	4:34	25.0	42.2	36,191
Empty Train meet @ km 100 Loaded Train leaves 1:14 min after Empty Train	21,864	15,344	5,037	45.0	2:55 (30 min siding time)	34.5		

APPENDIX 3

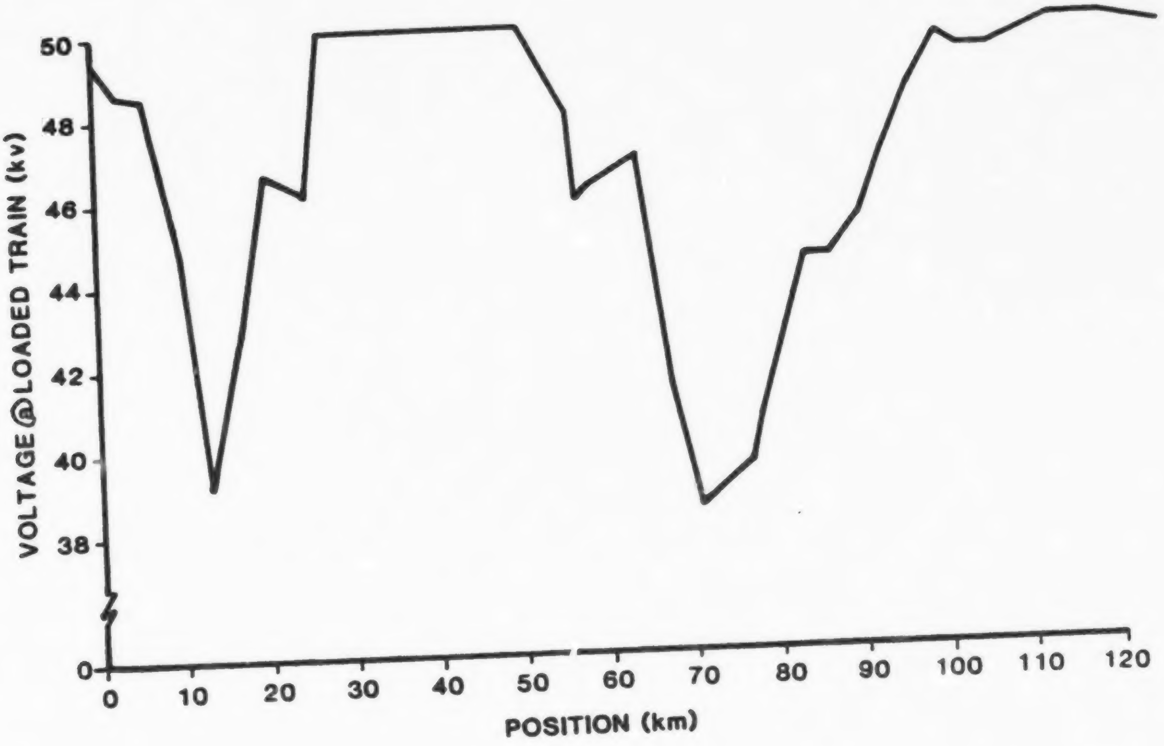
VOLTAGE PROFILE

LOADED TRAIN OPERATION ONLY



Max. speed 35 mph
Max. power 15,000 kw at pantograph

EMPTY AND LOADED TRAIN OPERATION



Max. combined power: 36,000 kw

APPENDIX 2

LONG TUNNEL OCS DESIGN REPORT

BRITISH COLUMBIA RAILWAY

Canadian Pacific Consulting Services Ltd.
CANAC Consultants Ltd.
Swederail Consulting Ltd.

TUMBLER RIDGE BRANCH LINE
50 KV - TUNNEL ELECTRIFICATION

Overhead Contract System Detailed Design Report

VOLUME 1

April 30, 1983

CONSULTING
ENGINEERS

INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY

HEADQUARTERS OFFICE
180 HOWARD STREET
SAN FRANCISCO, CALIFORNIA 94105 USA
TELEX: ITT 470040, RCA 278362, WUD [illegible]
PHONE (415) 442-7300

TECHNICAL MEMORANDUM #3032-TM/4
BRITISH COLUMBIA RAILWAY
TABLE TUNNEL AND WOLVERINE TUNNEL
50 kV ELECTRIFICATION

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C. OCS ACCEPTANCE DOCUMENT

D. CONSTRUCTION SUPPORT TASKS

E. DESIGN STATEMENTS

F. GLOSSARY OF TERMS FOR TRACTION ELECTRIFICATION

VOLUME 2 - CALCULATIONS

TECHNICAL MEMORANDUM #3032-TM/4
BRITISH COLUMBIA RAILWAY
TABLE TUNNEL AND WOLVERINE TUNNEL
50 kV ELECTRIFICATION

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C. OCS ACCEPTANCE DOCUMENT

D. CONSTRUCTION SUPPORT TASKS

E. DESIGN STATEMENTS

F. GLOSSARY OF TERMS FOR TRACTION ELECTRIFICATION

4.0 OVERHEAD CONTACT SYSTEM FINAL DESIGN

4.1 INTRODUCTION

4.1.1 Background

British Columbia Railway Company (BCR) is presently constructing 134 kilometers (84 miles) of branchline to service the North East Coal Block. The route is from Anzac to the Tumbler Ridge area through mountainous terrain and includes two major tunnels with a total length of 15 kilometers, two minor tunnels, and eleven bridges, with connections to loadout loops at two coal mines (see map, Figure 4-1).

BCR's decision to electrify the Tumbler Ridge Branch Line was the result of an electrification study prepared by Canadian Pacific Consulting Services Ltd. and Canac Consultants Limited, which was issued in April 1982. The study recommended a 50-kV system to haul the loaded trains up and over the crest of the Rocky Mountains. A convenient lower supply was located near the Tumbler Ridge townsite, and a 50-kV system required only a single lineside substation, while several would be required for a 25-kV system. The report also recommended the use of the Swedish State Railway (SJ) design for the overhead contact system, which had been prepared for the proposed electrification of the Quebec-Cartier Mining rail line.

4.1.2 IECO Participation

In June 1982, IECO was contracted by Canadian Pacific Consulting Services Ltd. (CPCS) to design the overhead contact system through the Table Tunnel (9 km long) and the Wolverine Tunnel (6 km long). The following telex from CPCS, which authorized the IECO services, also defined the scope of work for the design:

"Confirming conversation date we would like IECO to undertake:

a) Rough fixed tension catenary design for 750 amperes traction current for tunnel sections providing position support spacing at a height which will place the contact wire 6.0 meters minimum above the track.

b) Design of support brackets and cantilevers for tunnel sections and provide drawings for their manufacture and procurement.

c) Design rock bolt configuration for immediate installation in tunnel by tunnel contractor and provide drawings for his use.

d) Complete final design and layout of catenary in tunnel section and provide installation drawings and specifications. We believe fixed tension tunnel section should begin at least two spans outside of tunnel and extend for a minimum of 2.0 km in tunnels."

Subsequently, the contract was extended to include a feeder wire through the tunnels supported by the catenary supports.

Tunneling was already in progress so before the conceptual design of the catenary system could be started, the design and location of the rock bolts was prepared. This enabled immediate installation by the tunnel contractors. Upon completion of this task, the conceptual design was commenced, and the work has since proceeded through completion of final design.

4.1.3 Purpose of this Report - Technical Memorandum #3032-TM/4

As part of its design services, IECO has issued three previous Technical Memoranda, which are described in Section 4.2. This report serves as a summary of the design work performed by IECO on the electrification of the Table and Wolverine Tunnels. It differs from Technical Memorandum #3032-TM/3 in the following ways:

1) It incorporates the running of the feeder wire through both tunnels and any changes due to this modification.

2) It includes changes due to the comments on Technical Memorandum #3032-TM/3 by CPCS.

3) It incorporates minor changes to support arms in the first tension sections inside the tunnels to permit reduced conductor tensions throughout the tunnel.

4) It incorporates the relocation of the catenary change-over adjacent to Wolverine east portal and other minor adjustments that have occurred in finalizing the design.

The drawings prepared for final design have been modified to reflect these changes, as follows:

The feeder wire is being terminated at the end of each tunnel in the changeover arrangement, and this will require a new termination assembly as shown on Drawing 3032-5-3011. Four site-specific changeover arrangement drawings are added for each tunnel face as follows:

3032-B-4006	Changeover	Table Tunnel - East
3032-B-4007	Changeover	Table Tunnel - West
3032-B-4008	Changeover	Wolverine Tunnel - East
3032-B-4009	Changeover	Wolverine Tunnel - West

Reduction of conductor tensions in the first tension sections inside each portal has been achieved by providing strain compensation at every messenger support point. This is achieved by allowing the messenger to pass over a pulley, thereby avoiding the strain differential at a support that would be created by a sharp temperature gradient. The temperature differential between the air outside the tunnel and the air deep inside the tunnel is specified as -50°C to +6°C. The actual minimum length of tunnel over which the temperature change occurs cannot be evaluated until after the tunnel has been completed. In the meantime it is stipulated to be not more than 1 kilometer. By adopting pulley supports in these areas of the tunnels the possibility of severe strain differentials due to steep temperature changes in a very short distance has been safeguarded.

Details of the tunnel supports with pulleys are given on 4 new drawings:

3032-3-4004	Catenary transition overlap arrangement
3032-4-4003	Transition catenary span set, SM-3
3032-5-4008	Catenary support assembly CS-7
3032-6-4004	Components - Sheet 4

Also 3032-5-4002 Rev. 1, is issued to supercede the previous issued drawing.

Layout schedules, materials schedules, bills of materials and assembly lists are updated to reflect all engineering changes. Also design statements and calculations have been amended as necessary.

An additional Technical Sheet (3032 Sheet 4030/1) is included to give stringing tensions for the installation of all conductors.

4.2 PREVIOUS REPORTS

This report is the fourth report issued by IECO on the design of the overhead contact system for the Table and Wolverine Tunnels. Previous reports are:

- Technical Memorandum #3032-TM/1 (dated 19 July 1982) entitled "Tunnel Rock-Bolt Fixing Design for the Overhead Contact System Supports".

- Technical Memorandum #3032-TM/2 (dated 20 October 1982) entitled "Overhead Contact System Conceptual Design".

- Technical Memorandum #3032-TM/3 (dated 7 January 1983) entitled "Overhead Contact System Detailed Design Report".

Rock bolts for the catenary supports are being installed in accordance with Stationing Drawings 3032-B-4001 to 4003 for Table Tunnel and 3032-B-4005 for Wolverine Tunnel. These drawings were previously issued in preliminary form with Technical Memorandum TM/1 as Drawing 3032-B-1001 (5 sheets). The difference between the two issues is that the final design shows one rockbolt repositioned in each overlap.

Memorandum TM/2 describes the design decisions and philosophy that have been adopted in the development of the conceptual design drawings of the overhead contact system for both Table Tunnel and Wolverine Tunnel.

Memorandum TM/3 describes the design decisions and philosophy that have been adopted in the development of the final design drawings. Besides the text of the report, TM/3 included five appendices and other design analyses, as follows:

- Project Technical Handbook of technical sheets which outline project data and design criteria.
- Detailed Design Drawing Index.
- Overhead Contact System Acceptance Document.
- Construction Support Tasks.
- Glossary of Terms relating to the overhead contact system.

- Design Statements:

  DS/1 - Security of catenary rock bolts against corrosion.
  DS/2 - Rake requirements for stand off pipes.
  DS/3 - Choice between T-bar and tubular cross arms.

DS/4 - Limits of fixed termination catenary, feeder and ground wire.

DS/5 - Installation of feeder and ground wires.

DS/6 - Pantograph sway analysis.

- Design Calculations:

  3032-11 - Structural design of tunnel catenary support

  3032-12 - Tension and sags of conductor - system height

  3032-13 - Steady arm uplift under radial load

  3032-14 - Contact wire height

  3032-15 - Tension and sag of feeder and ground wire

  3032-16 - Electrical clearance criteria

  3032-17 - Midspan offset

  3032-18 - Conductor stringing

  3032-19 - Hanger lengths

4.3 BASIS OF DESIGN

The essential data and criteria specified for use in the tunnel overhead design have been obtained from the following sources:

- Initial data and criteria supplied by CPCS and BCR at the outset of the design.

- Information supplied and decisions made during the various design review meetings held with IECO and CPCS.

- Standards, codes and other accepted parameters conventionally applied to railroad electrification projects in North America.

- Swedish catenary design including components and component references supplied by CPCS.

- Rock bolts and the fixing arrangement to be consistent with the rock bolts used in construction of the tunnels.

- Specification by CPCS of conductor sizes and materials.

Conductors

As a result of power system studies performed by CPCS, the following conductor sizes were specified:

-	Messenger Wire	70 mm^2	H.D. Copper
-	Contact Wire	107 mm^2	Grooved H.D. Copper
-	Feeder Wire	70 mm^2	H.D. Copper
-	Aerial Groundwire	70 mm^2	H.D. Copper

Components

Wherever possible Swedish State Railway component designs that are used on other sections of the line have been selected for Table and Wolverine Tunnels.

Support Locations

Locations of rock bolts were given by IECO in Memorandum TM/1 and were based on 50-meter spans between supports on tangent track. If in fact the rock bolts have been installed at 49-meter spacings, resulting an increased number of supports, it will be necessary to redesign the stagger arrangement at the exits of the tunnels to marry into the auto-tensioned catenary.

Design Criteria

The final design criteria are specified in Technical Sheets #3032 Series (see Appendix A).

4.4 FINAL DESIGN DRAWINGS

The final design drawings comprise the fully developed SITE-SPECIFIC drawings and ELECTRIFICATION STANDARD drawings. A list of final design drawings is given in Appendix B. The drawings themselves have been submitted separately from this Technical Memorandum TM/4.

The heirarchy of drawings (shown on Dwg. 3032-1-4002 and in Figure 4-2) defines the interrelationships between different types and levels of drawings.

Site-specific drawings such as layouts and layout schedules show the stationing of OCS supports, contact wire stagger and other dimensional details. The Material Schedules, which have been prepared on a one-for-one basis with the layout schedules, show all the assemblies required per location. A conductor schedule has been prepared for each tunnel, giving a conductor description with individual tension section lengths for the feeder and ground wire, within the termination limits given in Design Statement DS/4. All components required for the fixed termination section of the tunnel catenary, as specified in the layout and material schedules, are given in the component list with component quantities in Drawing Numbers 3032-E-4001 through 4004.

The drawing numbers, as shown in the hierarchy, are suffixed with a "4000" series for final design and they will supersede all previous issues.

4.5 APPLICATION OF FINAL DESIGN DRAWINGS

The final design drawings include all final revisions and additions discussed in this Technical Memorandum #3032-TM/4.

The overhead contact system acceptance document is given in Appendix C. The site checks and tests are covered in the construction support tasks given in Appendix D, see Section 4.6.

In this Technical Memorandum the revised Design Statements and the Glossary of Terms are found in Appendices E and F, respectively.

4.6 CONSTRUCTION SUPPORT TASKS

With the continuining construction of the tunnels, access to the catenary rockbolts for construction of the catenary is not possible due to the presence of the 5 ft. ventilation pipe. In order not to delay construction of the catenary as and when the pipe is removed, it is expedient that a number of pre-electrification design checks will be conducted and these are listed in Appendix D.

APPENDIX 3

LIST OF DRAWINGS

LIST OF SPECIFICATIONS

LIST OF DRAWINGS

Drawing Number	Item
C-82079-02-001	Pole type C130 x 10 and type C130 x 13
C-82079-02-002	Pole type C150 x 16
C-82079-05-005	Pole type C250 x 30
C-82079-05-006	Pole extension
A2/7-21457	Concrete pedestal base for type II standard pole foundations
A2/7-21466	Base plates for type I & III pole foundations
A2/7-21482	Assembly and fastening details for type I, II and III
A2/7-21484	Catenary pole sections and details showing bolt centres
4-503045	Support loop for dropper
3-503046	Steering ring for tensioning weights
3-503048	Tube link for 27 mm tube
3-503049	Clevis joint for cantilever
3-503050	Tube socket for 55 mm tube
3-503051	Tube fitting for cantilever with 55 or 54 mm tube
4-503053	Top-tie for cantilever
4-503054	Tensioning counterweight suspension rod
3-503055	Link
3-503056	Wedge clamp for stranded flexible or 35 mm^2 wire
3-503057	Tensioning pulley fork
4-503061	Pin 19 x 100
4-503062	Pin 19 x 54
4-503063	Tensioning pulley axle
3-503064	Square pole - portal cantilevers
3-503065	Cross link for tensioning equipment
3-503066	Tensioning link
3-503067	Pulley for weight tensioning
1-503068	Pulley (casting) for weight tensioning
4-504069	Link
4-503072	Stud for 50 and 70 mm^2 wire messenger wire support

Drawing Number	Item
4-503073	Back plate
3-503076	Clamp for 2 wires in messenger wire channel
4-503077	Tensioning link
2-503078	Tensioning balance
3-503081	Wedge clamp for 107 mm^2 contact wire, 70 mm^2 and 50 mm2 wires
4-503082	Portal structure B76 joint set 90
4-503083	Mounting iron 90 for portal structure B76 (with 4 holes)
4-503084	Mounting iron 90 for portal structure B76 (with 6 holes)
3-503085	Portal structure B76 joint piece
4-503089	Pin 16 x 45
4-503090	Retainer pin
4-503091	Portal structure B76 member joint set 97
4-503092	Mounting iron 97 for portal structure B76 (with 4 holes)
4-503093	Mounting iron 97 for portal structure B76 (with 6 holes)
3-503094	Portal structure B76 joint piece 97
4-503095	Waxing of nuts
3-503096	Wire connector
3-503097	Contact wire clamp
3-503107	Portal structure B76 member, portal mount
3-503108	Portal structure B76 member, cross bar
4-503109	Threaded hook fastener 3/4 UNC x ___ SAE GR 8
4-503110	Threaded hook fastener 1/2 UNC x ___ SAE GR 8
3-503111	Tensioning counter weight - 22 kg
3-503112	Socket for contact wire clamp
3-503113	Socket for contact wire clamp
3-503114	Socket for contact wire clamp
4-503115	Hex bolt 1/2 - 13 UNC SAE GR 8
4-503116	Pin 13 x 44
2-503117	Portal structure B76 end structure V
2-503118	Portal structure B76 end structure H
2-503119	Portal structure B76 intermediate structure
4-503121	Bracket insert for 42 mm tube

Drawing Number	Item
4-503122	Messenger wire channel for 70 mm^2 wire
4-503122-1	Messenger wire channel for 70 mm^2 wire
4-503122-2	Messenger wire channel for 70 mm^2 wire
4-503122-3	Messenger wire channel for 70 mm^2 wire
3-503123	Messenger wire channel for 70 mm^2 wire
3-503124	Clamp for messenger support 70 mm^2 wire
2-503125	Hinge for cantilever bracket
4-503127	U-bolt with nuts for 42 mm tube
2-503128	Cantilever pivot bracket
3-503130	Bracket for suspension of earth wire
2-503131	Mounting beam for twin-arm cantilever
3-503132	Hinge holder
3-503133	Mounting beam for common automatic tensioning
3-503134	Lower bracket for guide tube
4-503135	Upper bracket for guide tube
4-503136	Head of attachment assembly
4-503137	Head of fastener clamp
4-503138	Tensioning holder
4-503139	Tensioning holder
3-503140	Steady arm
3-503141	Steady arm hook
3-503142	Steady arm tube
3-503143	Steady arm socket
3-503144	Catenary hanger
4-503146	Rod insulator cap
4-503147	Lug on cap for rod insulator
3-503148	Cap for top-tie insulator
2-503150	Rod insulator 350-140 kV for 55 mm tube and clevis
3-503260	Portal structure B76 summary
3-503261	Portal structure B76 parts
3-503262	Portal structure B76 joint
3-503267	Portal structure B76 mounting alternatives
2-503272	Rod insulator for 350-140 kV for clevis to top-tie
4-503273	Clevis type suspension insulator

Drawing Number	Item
4-503274	Dropper
3-503275	Guy for mid-point anchor
4-503278	Eye for dropper
4-503279	Dropper for tunnel
3-503280	Dropper for tunnel, suspension loop length 150 mm
3-503281	Dropper for tunnel, suspension loop length 240 mm
3-503282	Dropper for tunnel, suspension loop length 340 mm
4-503283	Protective channel for tunnel dropper
2-503285	Weight tensioning 9.8/9.8 kN and 6.0/6.0 kN on C130 x 13 and C150 x 16
3-503286	Adjustment on balance arm 04 15 117-1
3-503287	Single cantilever
2-503288	Twin-arm cantilever for overlap span
2-503289	Twin-arm cantilever for switch
2-503290	Overlap jumper
4-503410	Potential equalizer
2-503411	Mid-point anchor
4-503412	Cantilever in portal structure, list of items
1-503412	Cantilever in portal structure, list of items
4-503413	Tensioning holder
4-503414	Protective cap for 54 mm tube
3-503415	Cantilever in inner curve, R - 291 - 388 m
4-503416	Square pole mounting bar
3-503417	Fixed tensioning assembly drawing
2-503418	Twin-arm cantilever with electric section for switches
3-503419	Bracket for feeder wire insulator
3-503420	Earth wire suspension
3-503421	Tube link for 42 mm tube
3-503422	Clevis link
3-503424	Tube connector for 42 mm tube
2-503425	View of overhead equipment single cantilever pole

Drawing Number	Item
3-503426	Feeder wire suspension
3-503427	Overlap span
3-503428	Tensioning insulator
3-503429	Extension bracket for mounting of earth wire
3-503430	Adjustment of cantilevers, single cantilever
3-503431	Adjustment of cantilevers, twin-arm cantilevers
3-503433	List of cantilever set, single cantilevers
3-503434	List of cantilever set for inner curves and mid-point anchor
3-503436	List of cantilever set, twin-arm type C & D
3-503437	List of cantilever set, twin-arm type E & F
3-503438	List of cantilever set, twin-arm for switch
3-503439	List of cantilever set, twin-arm earth electric section for switches
3-503565	Earth wire suspension
3-503566	Extension bracket for mounting of earth wire suspension (C250 x 30)
2-503567	Earth and feeder wire positions at crossing span
2-503568	Earth and feeder wire positions at anchoring point
3-503569	Earth and feeder wire positions at overlap span
4-503570	Hinge bracket
3-503571	Space length - 1000 mm
4-503572	Distance bar between messenger and contact wire
2-503573	Twin-arm cantilever for overlap span in portal structure
4-503574	Bracket for feeder wire insulator at portal structure
4-503575	Angle bar for square pole mounting
3-503476	Bracket for pulley fork
3-503477	Pulley fork
3-503478	Pulley
3-503579	List of cantilever set, single cantilever at mid-point anchor
3-503580	Head of attachment
4-503581	Attachment for steady arm

Drawing Number	Item
2-503582	Mid-point anchor in portal structure
2-503583	Twin-arm cantilever for overlap span in portal structure
4-503583	List of items (refer to 2-503583)
4-503584	Washer part no. 04-13-090-2
2-503656	Weight tensioning 9.8/9.8 kN on C250 x 30
3-503657	Mounting beam for common automatic tensioning
3-503658	Bracket for pulley
3-503659	Cantilever with support in auto-tensioning sections of tunnels
3-503660	Cantilever with support in auto-tensioning sections of tunnels
3-503661	Cantilever for Parsnip River Bridge, Type A
3-503662	Cantilever for Parsnip River Bridge, Type B
3-503663	Portal structure general arrangement single cantilever
3-503664	Portal structure general arrangement twin-arm cantilever
3-503665	Portal structure general arrangement twin-arm cantilevers
3-503666	Portal structure general arrangement twin-arm cantilevers
3-503668	Tension table for 125 mm^2 ACSR wire
3-503669	Mid-point anchor
3-503670	Spacer, L - 1700 mm
3-503672	Feeder jumper
2-503673	Fixed end of feeder and earth wire
4-503674	Attachment for registration support
3-503676	Feeder wire suspension at portal structure
3-503678	Overlap jumper in portal structure
2-503679	Switch jumper
3-503776	Clevis link
2-503779	Ground jumper
4-503780	Grounding wire bracket
4-503781	Cantilever dropper
3-503783	Parsnip River Bridge pendulum suspension of earth wire

Drawing Number	Item
3-503785	Feeder wire dead end and surge arrestor arrangement
3-503786	Overhead equipment arrangement outside tunnel, type 1
3-503787	Overhead equipment arrangement outside tunnel, type 2
3-503788	Overhead equipment arrangement outside tunnel, type 3
0-503790	Loadout, Late Building and Clamshell area
3-504142/1	Table of droppers 9.8/9.8 kN system height 1300/1300
3-504142/2	Table of droppers 9.8/9.8 kN system height 1300/1300
3-504142/3	Table of droppers 9.8/9.8 kN system height 1300/1300
3-504142/4	Table of droppers 9.8/9.8 kN system height 1300/1300
3-504142/5	Table of droppers 9.8/9.8 kN system height 1300/1550
3-504142/6	Table of droppers 9.8/9.8 kN system height 1300/1550
3-504142/7	Table of droppers 9.8/9.8 kN system height 1300/1700
3-504142/8	Table of droppers 9.8/9.8 kN system height 1300/1700
3-504142/9	Table of droppers 9.8/9.8 kN system height 1300/900
3-504142/10	Table of droppers 9.8/9.8 kN system height 1300/900
3-504142/11	Table of droppers 9.8/9.8 kN system height 1300/2100
3-504142/12	Table of droppers 9.8/9.8 kN system height 1300/2100
3-504142/13	Table of droppers 9.8/9.8 kN system height 200/2100
3-504142/14	Table of droppers 9.8/9.8 kN system height 200/2100
3-504142/15	Table of droppers 9.8/9.8 kN system height overlap span
3-504142/16	Table of droppers 9.8/9.8 kN system height Parsnip River Bridge
3-504142/17	Table of droppers 9.8/9.8 kN system height auto-tensioned tunnel sections
3-504142/18	Table of droppers 5.9/5.9 kN system height 1300/1300
3-504142/19	Table of droppers 5.9/5.9 kN system height 1300/1550
3-504142/20	Table of droppers 5.9/5.9 kN system height 1300/1700
3-504142/21	Table of droppers 5.9/5.9 kN system height overlap span
3-504143	Portal structure general arrangement, single cantilever - four tracks
3-504144	Portal structure general arrangement, 113-11, -11a; 113-12, -12a

Drawing Number	Item
3-504145	Portal structure general arrangement, 112-16, -16a
3-504146	Cantilever diagram stagger and cantilever set for single cantilevers
3-504147	Cantilever diagram stagger and cantilever set for twin-arm cantilevers
2-504150	Neutral section
2-504151	Connecting point disconnector at switch
2-504152	Connecting point disconnector for feeding back track
1-504153	Connecting point disconnector for feeding siding and back track
4-504154	Angle bar for insulator
3-504156	Surge arrestor platform
2-504157	Connecting point overlap section with disconnector
3-504158	Overlap span with disconnector - dropper table
3-504159	Back plate
3-504160	Bracket for suspension of earth wire (for C250 pole)
3-504161	Bracket for feeder wire insulator
2-504739	Contact bar
2-504740	Contact bar
2-504741	Brackets for portal
2-504742	Portal
2-504743	Insulator bracket
2-504744	Holder of pull rod
2-504745	Yoke
3-504746	Bracket for yoke
3-504747	Jounal bearing for yoke
4-504748	Attachment plate for insulator support
4-504749	Shaft for pull rod
4-504750	Pull rod
4-504751	Securing plate
4-504752	Washer
4-504753	Mounting of insulator on insulator support and tensioning support
2-504754	Insulator support
2-504755	Daylight zone entrance assembly

Drawing Number	Item
3-504756	Bracket for brake
4-504757	Attachment plate
4-504758	Brace attachment
4-504759	Brace
2-504760	Insulator to neutral section assembly drawing
3-504761	Contact bar assembly
2-504762	Safety chain for spring tensioning
3-504763	Tensioning spring
3-504764	List of drawings
4-504765	List of components
1-504766	Modified section insulator
2-504768	Tensioning support
2-504866	Tensioning support
3032-3-4001	Catenary overlap arrangement
3032-3-4002	Ground wire transition arrangement
3032-3-4003	Catenary transition overlap arrangement
3032-4-4001	Standard catenary span set, SM-1
3032-4-4002	Standard catenary span set, SM-2
3032-4-4003	Standard catenary span set, SM-3
3032-5-4001	Catenary support assembly CS-1
3032-5-4002	Catenary support assembly CS-2
3032-5-4003	Catenary support assembly CS-3
3032-5-4004	Catenary support assembly CS-4
3032-5-4005	Catenary support assembly CS-5
3032-5-4006	Catenary support assembly CS-6
3032-5-4007	Grounding assemblies GD-1, GD-2, GD-3
3032-5-4008	Catenary support assembly CS-7
3032-5-4009	Jumper assembly JU-1, JU-2, JU-3
3032-5-4010	Support and insulation assemblies WS-1 & WS-2
3032-5-4011	Dead end assemblies DE-1, DE-2, DE-3
3032-5-4012	Bridle assembly BR-1
3032-6-4001	Components
3032-6-4002	Components
3032-6-4003	Components
3032-6-4004	Components

List of Specifications

a) Specification for Overhead Line Equipment Hardware dated December 1982.

Covers the design, manufacture, testing and supply of various items of overhead line equipment hardware. To ensure compatibility of the various components when assembled, they are identified in sets and packages. Suppliers were required to quote upon the provision of complete packages.

b) Portal Structure Specification dated March 1983.

Covers the fabrication, testing and delivery of portal structure members required for supporting the overhead wiring in multi-track sections of the TRBL.

c) Insulator Specification dated March 1983.

Covers the design (where necessary), the manufacture, factory testing and delivery of insulators required for the overhead system. Special requirements such as section insulators were specified separately.

d) Steel Tube for Cantilevers dated February 1983.

Covers the design, manufacture, factory testing and delivery of steel tubing which is used for the cantilevers which support the overhead wires.

e) Bolt Specification dated February 1983.

Covers the supply and delivery of various standard bolts and nuts as well as the fabrication, supply and delivery of some special ones.

f) Miscellaneous Hardware Specification dated February 1983.

Covers the supply and delivery of miscellaneous, standard and off-the-shelf hardware such as guy rods, anchors, guying dead ends, exothermic connectors for connecting earth return wire to rail, clamps, etc.

g) Fabricated Tunnel Hardware Specification dated February 1983.
Covers the fabrication, supply and delivery of various steel members required to construct the tunnel supports of the OCS.

h) Wire Specification dated January 1983.
Covers the manufacture, supply and delivery of wire cable, joints and dead ends for the OCS, contact wire, messenger wire, feeder and return circuits, ground wire, guy strands, dropper wire and jumper wire.

i) Specification for Section Insulators and Neutral Sections dated February 1983.
Covers the physical, mechanical and electrical requirements for the insulators required to isolate sections of the line.

j) Specification for Steel Wire Rope dated January 1983.
Covers the design, manufacture and supply of stainless steel wire rope required for the automatic weight tensioning equipment of the OCS.

k) Dropper Specification dated April 1983.
Covers the fabrication of droppers (also called hangers) which will suspend a contact wire from a messenger wire.

l) OCS of Load Loops Specification dated July 1983.
Covers a description of the OCS at the loadout loops at Quintette and Teck mines.

m) Specification on Foundation and Pole Installation dated February 1983.
Covers the installation of the foundations and poles to support the OCS.

APPENDIX 4

LIST OF FIRMS RESPONDING TO TENDERS FOR MATERIAL

FIRMS RESPONDING TO TENDERS

Miscellaneous Hardware

Kupler
Joslyn
O.B. Canada
Nedco
AB Chance

Tubing

EBCo
Wirsbo Bruks AB

Nuts and Bolts

Malkin & Pinton
Lister Bolt & Chain

Tunnel Hardware

Inlet Metal
Northern Steel

Overlap Insulators

Patton & Cooke
O.B. Canada
John McMillan (Electric Power Accessories Co. Ltd.)

Section Insulators

Gordon Russell (Brown Boveri)
O.B. Canada
Balfour Beatty
Kupler Corp.

Wire

Phelps Dodge Corp.
Canada Wire & Cable
Phillips Cables
Alcan Canada
Anixter-Turmac
Siemens Canada
Anaconda Ericsson

Wire Fittings

Burndy
Alcan
Gescan
Westinghouse Canada
E.B. Horsman
Erico Canada
Van Horne
Slacan
Balfour Beatty
Nedco

Clamps

Swedish State Railways (SJ)
Siemens
Gordon Russell
Joslyn
O.B. Canada
Balfour Beatty

Steel Rope

Greening Donald
Wesco Industries

Supply of Poles

Northern Steel
EBCo Industries Ltd.
Dancan
Beales
B.C. Mill Machinery
Weldco
Delta
Canron
Engineering & Machinery

H-Beam Piles

Algoma Steel
Rovaco Steel
Dominion Bridge
Trade Arbed Canada
Chatham Steel
L.B. Foster

Footing Plates

Canron
EBCo Industries Ltd.
Q.M. Machinery
Northern Steel
Dominion Bridge
B.C. Mill Machinery
Mainland Machinery
Inlet Metal
Weldco
ACO Industries
P.G. Fabricating
Burrard Mechanical
Dancan

Steel Rope (Cont'd)

Western Industrial Supplies
B.C. Wire Rope
Gunnebo Bruks AB
Comor Supplies

Portals

L.A. Steel
Dancan Manufacturing
EBCo Industries Ltd.
Northern Steel
Mainline Machinery
PB Fab & Eng
Burrard Mech
Canron
XL Iron Works
Wilson Steel
N & M Welding
B.C. Mill Machinery
Dominion Bridge
Western Dominion Steel

OCS Hardware

EBCo Industries Ltd.
Malkin & Pinton
Weldco
Lister Bolt & Chain
Joslyn Industries
Slacan
B.C. Mill Machinery
Trydor Engineering
Dominion Bridge
Patton & Cooke

Footing Plates (Cont'd)

L.A. Steel
Linden Welding

Concrete Pedestals

Ocean Construction
Dywidag Fabcon Products
Genstar
McKenzie Ready Mix

Insulators

NGK Industries
Cegelec
O.B. Canada
Joslyn Industries
Rosenthal
Siemens
Nelson Machinery

*Northern Steel
*EBCo Industries
Dancan
Beales
B.C. Mill Machinery
Weldco
Delta
Canron
Engineering & Machinery
*Algoma Steel
Rovaco Steel
Dominion Bridge
Trade Arbed Canada
Chatham Steel
L.B. Foster
Q.M. Machinery
Mainland Machinery
Inlet Metal
ACO Industries
P.G. Fabricating
Burrard Mechanical
*L.A. Steel
Linden Welding
*Ocean Construction
Dywidag Fabcon Products
Genstar
McKenzie Ready Mix
XL Iron Works
Western Dominion Steel
Malkin & Pinton
Lister Bolt & Chain
N & M Welding
Joslyn Industries
Trydor Engineering
*NGK Industries
CEGELEC
*O.B. Canada
Rosenthal
*Siemens
Nelson Machinery
*Kupler
*Nedco
A.B. Chance
*Wirsbo Bruks AB
*John McMillan
*Gordon Russell (BBC)
Balfour Beatty
Phelps Dodge
*Canada Wire & Cable
Philips Cables
Alcan
Anixter-Turmac
Anaconda Ericsson
Burnday
Gescan
Westinghouse
E.B. Horsman
Erico
Van Horne
*Swedish State Railways (SJ)
*Greening Donald
Wesco Industries
Western Industrial Supply
B.C. Wire Rope
Gunnebo Bruks AB
Comor Supplies
Slacan
Patton & Cooke

*Awarded Contracts

APPENDIX 5

SUPPORT STRUCTURES

POLES
POLE FOUNDATIONS
PORTALS

DESIGN AND SOURCING - POLES

1. Four sizes of poles were required to cater to the various loadings encountered on the TRBL. The four sizes plus an extension are as follows:

POLE TYPE	ABBREVIATED DESIGNATION	DRAWING NUMBER
C130 x 10	C10	C-82079-02-001
C130 x 13	C13	C-82079-02-001
C150 x 16	C16	C-82079-02-002
C250 x 30	C30	C-82079-02-005
Extension	Ex	C-82079-02-006

2. The C130 x 10 pole is the most common type being used on the inside curves and on tangent track sections to support the feeder wire, ground wire and a single cantilever for the messenger and contact wires. The C130 x 13 pole is used where heavier loadings are encountered such as the outside of sharp curves or to support additional loadings such as weight tensioning units, fixed anchors, etc., in addition to the feeder wire, ground wire and single cantilever for the messenger and contact wires. A pole extension is sometimes used on C130 x 13 poles to accommodate crossovers from one side of the track to the other. The extension is specifically designed for a C130 x 13 pole although it can also be used to extend a C150 x 16 pole. The C150 x 16 pole is used to support a double cantilever, for example at overlaps and switches. The C250 x 30 poles are used whenever portal spans are required to support overhead contact system components over multiple track sections (three or more tracks).

3. The material required was tendered December 1, 1982 with a closing date of December 22, 1982 for the following quantities:

POLE TYPE	QUANTITY	ABBREVIATED DESIGNATION
C130 x 10	ea. 1100 to 1400	(C10)
C130 x 13	ea. 500 to 800	(C13)
C150 x 16	ea. 250 to 350	(C16)
C250 x 30	ea. 125 to 175	(C30)

4. Nine manufacturers responded. Prices, delivery and productions rates are summarized on the following page. The following summary of costs is based on the quotations for short poles.

POLE TYPE	HIGH	LOW	AVERAGE	CONTRACTED
C130 x 10	$ 460	$341	$410	$340.78 EBCO
C130 x 13	536	415	485	415.24 EBCO
C150 x 16	607	491	552	490.85 EBCO
C250 x 30	1,119	882	969	882.45 EBCO
Extension	214	85	136	111.42 L.A. Steel
Total	$1,465,362	$1,139,774	$133,2,065	$1,141,124

Note: Pole extensions were tendered with portal material and purchased from the lowest overall bidder.

ENQUIRY NO. P233

REVIEW NO.

DATE OF ENQUIRY

CLOSING DATE & TIME DECEMBER 22/82

F.O.B. PRINCE GEORGE

	PORTAL TYPE 1(a) LONG	PORTAL TYPE 1(b) SHORT	150 x 16 TYPE 2(a) LONG	150 x 16 TYPE 2(b) SHORT	130 x 13 TYPE 3(a) LONG	130 x 13 TYPE 3(b) SHORT	130 x 10 TYPE 4(a) LONG	130 x 10 TYPE 4(b) SHORT	TOTAL PRICE	DELIVERY SET UP & LEAD	DELIVERY WEEKLY PRODUCT RATE	MANUFACTURING LOCATION
QUANTITY - OPTION 1	100-150	20 - 40	200-300	40-100	400-700	100-200	900-1300	130-400				
NORTHERN STEEL	$ 1,088	$ 935	$ 613	$ 573	$ 472	$ 465	$ 388	$ 402	1,530,400	10 WEEKS	150-175	PRINCE GEORGE, BC
EBCO (NO TRIM TOLERANCE)	1,182	969	584	527	483	464	392	376	1,534,496	16 WEEKS	300	RICHMOND, BC
EBCO (NO TRIM TOLERANCE)	1,177	892	600	505	495	446	402	366	1,548,796	16 WEEKS	300+	RICHMOND, BC-FAB. PORTLAND, USA-GALV.
EBCO (TRIM TOLERANCE)	1,194	979	591	534	489	470	399	383	1,557,081	16 WEEKS	300	RICHMOND, BC
EBCO (TRIM TOLERANCE)	1,187	903	608	513	502	453	409	373	1,571,104	16 WEEKS	300+	RICHMOND, BC-FAB. PORTLAND, USA-GALV.
DANCAN	1,094	942	608	574	519	528	419	460	1,638,316	6 WEEKS	77-128	VANCOUVER, BC
BEALES	1,148	923	639	539	532	495	445	442	1,683,455	6 WEEKS	35-150	LANGLEY, BC
BC MILL	1,317	1,119	645	564	557	522	422	459	1,718,579	14 WEEKS	60-120	NEW WESTMINSTER, BC
WELDCO	1,211	994	654	625	548	519	445	446	1,725,389	TBA	50-200	VANCOUVER, BC
DELTA	1,294	1,056	678	607	557	519	433	444	1,733,858	8 WEEKS	0-175	DELTA, BC
CANRON	1,223	1,005	688	605	576	532	433	452	1,743,879		120-150	VANCOUVER
ENGINEERING & MACHINERY	1,154	939	695	630	583	549	481	471	1,813,500	9 WEEKS	40-60	DELTA
QUANTITY - OPTION II		125-175		250-350		500-800		1100-1400				
EBCO (NO TRIM TOLERANCE)		882		491		415		341	1,135,524	16 WEEKS	300+	RICHMOND, BC-FAB. PORTLAND, USA-GALV
EBCO (TRIM TOLERANCE)		893		499		422		347	1,154,857	16 WEEKS	300+	RICHMOND, BC-FAB PORTLAND, USA-GALV.
EBCO (NO TRIM TOLERANCE)		944		510		445		365	1,211,289	16 WEEKS	300	RICHMOND, BC
EBCO (TRIM TOLERANCE)		955		518		452		372	1,230,622	16 WEEKS	300	RICHMOND, BC
NORTHERN STEEL		908		552		481		404	1,302,500	10 WEEKS	150-175	PRINCE GEORGE, BC
BEALES		914		546		486		436	1,349,933	6 WEEKS	35-150	LANGLEY, BC
WELDCO		968		574		500		429	1,366,741	TBA	50-200	VANCOUVER, BC
DANCAN		921		571		515		453	1,406,865	6 WEEKS	77-128	VANCOUVER, BC
L.A. STEEL		1,099		593		536		428	1,427,875	13 WEEKS	100-150	SURREY, BC
CANRON		991		597		526		447	1,428,512	TBA	100-120	VANCOUVER, BC
DELTA		1,056		607		519		444	1,433,808	8 WEEKS	175	DELTA, BC
BC MILL		1,119		564		522		460	1,434,662	14 WEEKS	60-120	NEW WESTMINSTER, BC

POLE FOUNDATION MATERIAL

1. Design details are contained in the BCR report included in this appendix and the following BCR drawings: A2/7-21457, 21466, 21482 and 21484.

2. Quotations were obtained in four parts:

		Quantity
a)	Precast concrete pedestals - portal type	15
	- standard type	240
b)	H-Beam Piles - HP 10 x 42 x 50 ft. length	612
	- HP 10 x 42 x 40 ft. length	55
c)	Footing Plates - Standard	2,117
	- Portal	130
	- Rock anchors	405
d)	Bolts - 1-1/2" x 4-3/4" A325 bolts	517
	- 1-1/4" x 4-1/2" A325 bolts each c/w nut, flat washers and locking washers.	8,475

3. Precast concrete pedestals - four companies responded. (See summary at page 5-8).

TYPE	HIGH	LOW	AVERAGE	CONTRACTED
Portal type	$ 831.00	$ 369.30	$ 527.35	$ 476.80
Standard type	728.00	351.75	473.80	422.60
Total Order	227,435.00	147,651.00	173,814.00	147,651.00

Contracted Supplier - Ocean Construction Supplies.

4. H-Beam Piles - six companies responded. (See page 5-9).

ITEM	HIGH	LOW	AVERAGE	CONTRACTED
50 ft. lengths ea. 612	$31.71 Cwt	$22.71 Cwt	$27.62 Cwt	$22.71 Cwt
40 ft. lengths ea. 55	31.60 Cwt	22.71 Cwt	27.51 Cwt	22.71 Cwt
Total Order	$485,310	$404,484	$454,572	$404,484

Supplier - Algoma Steel Corporation Ltd.

5. Footing Plates - 15 companies responded. (See pages 5-10 and 5-11).

ITEM	HIGH	LOW	AVERAGE	CONTRACTED
Standard Plates	$65.75	$39.90	$48.07	$41.40
Portal Plates	75.14	50.16	58.15	50.15
Rock Anchor Plates	75.14	49.61	57.27	50.15
Total Order	$179,393	$115,662	$136,708	$118,569

Supplier - Northern Steel Ltd.

Three firms proposed alternates (late delivery, increased tolerances, different material). The low bid was one such alternate and was considered unacceptable.

6. Bolts - the purchase of the required bolts was directed to the firm of Malkin and Pinten which won the main contract for nuts and bolts (see Appendix 6).

Purchase price was as follows:

1-1/2" x 4-3/4" bolt c/w washers and nut	-	$7.70 each
1-1/4" x 4-1/2" bolt c/w washers and nut	-	$5.08 each
Total order	-	$46,997.17

7. Based on the foregoing, the price variations for pole foundation materials can be summarized as follows:

FOUNDATION TYPE	HIGH	LOW	AVERAGE	CONTRACTED
*H-Beam - Standard	$ 419.02	$ 298.67	$ 358.40	$ 300.17
*H-Beam - Portal	438.89	319.40	378.96	319.40
Precast - Standard	728.00	351.75	473.80	422.60
Precast - Portal	831.00	369.30	527.35	476.80
**Rock anchors - Standard	201.16	138.44	160.46	140.48
**Rock anchors - Portal	221.03	159.17	181.02	159.71
Total Order	$939,135	$714,794	$812,091	$717,701

* Based on an average of 25 ft. pile, footing plates and hardware.

** Based on an average of 3 ft. pile, footing plates, rock anchor plates and hardware.

8. In order to obtain a clearer picture of costs to be expected for various types of foundations and poles, it is necessary to review, in the case of poles and their foundations, the variations in installation costs. The installation of pole foundations and the erection of poles on those foundations was tendered for the eastern half of the TRBL. The installation of pole foundations and the erection of poles on those foundations for the section of the TRBL west of the long tunnels was negotiated with the contractor preparing the grade in that section. The pole foundation and the erection of poles on the remainder of the TRBL was undertaken by BCR crews. For the tendered portions, the installation costs varied as follows:

	HIGH	LOW	AVERAGE	CONTRACTED
Pile Foundations	$ 800	$200	$ 463	$237
Concrete Pedestals	1,350	410	688	475
Rock Anchors	2,000	750	1,227	750
Pole Erection	334	70	181	70

(Based on quotations received from 9 firms.)

9. Using the bid prices, the installed costs of poles varies depending on the pole type and foundation type as follows:

INSTALLED COST SUMMARY

POLE	FOUNDATION	HIGH	LOW	AVERAGE	CONTRACTED
C130 x 10	Type I	$2,013	$ 910	$1,412	$ 948
C130 x 13	Type I	2,089	984	1,487	1,022
C150 x 16	Type I	2,160	1,060	1,554	1,098
C250 x 30	Type I	2,692	1,471	1,992	1,508
C130 x 10	Type II	2,872	1,173	1,753	1,309
C130 x 13	Type II	2,948	1,247	1,828	1,383
C150 x 16	Type II	3,019	1,323	1,895	1,459
C250 x 30	Type II	3,634	1,731	2,365	1,904
C130 x 10	Type III	2,995	1,299	1,978	1,301
C130 x 13	Type III	3,071	1,373	2,053	1,375
C250 x 30	Type III	3,674	1,861	2,557	1,862

TABULATION

INQUIRY NO. P45

REQ'N NO.

DATE OF INQUIRY

CLOSING DATE, NOON

F.O.B. WOLVERINE CAMP

ROUTING VIA BCR

QUANTITY AND DESCRIPTION	LAST PRICE	OCEAN CONST. PRICE	DYWIDAG FABCON PROD. ALT. PRICE	DYWIDAG FABCON PROD. MAIN PRICE	GENSTAR PRICE	MCKENZIE READY MIX PRICE	PRICE	PRICE	PRICE	PRICE	PRICE
15 ONLY PORTAL TYPE PRECAST CONCRETE											
FOUNDATIONS PER BCR DWG.											
1R2/71458 COLOUR CODED WHITE		$ 476.80	$ 369.30	$ 426.30	$ 533.33	$ 831.00					
240 ONLY STANDARD TYPE PRECAST CONCRETE											
FOUNDATIONS PER BCR DWG.											
1R2/71437		$ 422.60	$ 351.75	$ 407.40	$ 459.23	$ 728.00					
TRANSPORTATION COST TO B.C. RAIL											
WOLVERINE CAMP		$39,075.	$58,410.	$58,410	$64,820.	$40,250.					
TOTAL COST DELIVERED		147,651	148,370	162,581	183,035	227,435					
(THEORETICAL TOTAL WT. IN TONNES)		781	807	807	746	735					
DELIVERY: SET UP TIME		2 WKS.	1 WEEK	1 WEEK	2 WEEKS FOR BOLTS	2 WKS					
RATE OF PRODUCTION		6 MIN. 12 MAX.	8	8	24	14					
TO SPECIFICATION		YES	(OCTAGON) NO	YES	YES	YES					
COUNTRY OF ORIGIN		PR. GEO. B.C.	ABBOTSFORD, BC.		RICHMOND BC	MACKENZIE BC.					
SALES TAX @ 5%		INCL.	INCL.	INCL.	INCL.	INCL.					
TERMS		NET 10TH	NET 30		NET 30	NET 30 AFTER COMPLETION AND MONTHLY PROGRESS					

TABULATION

INQUIRY NO P-52
REQ'N NO
DATE OF INQUIRY Mar 2/83
CLOSING DATE, NOON Mar 10/83

F.O.B. B.C.R. Wolverine Camp

QUANTITY AND DESCRIPTION	LAST PRICE	ALGOMA STEEL	ROVACO STEEL	DOMINION BRIDGE	TRADE ARBED CANADA	CHATHAM STEEL	L.B. FOSTER					
		PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE
612 Lengths Steel Bearing Pile HP 10 @ 42 Lbs./Ft		$ 22.71 Cwt	$25.57 Cwt	$30.73 Cwt	$31.71 Cwt	$27.41 Cwt	$31.28 Cwt 250 len. only					
50 Ft/Length												
55 Lengths Steel Bearing Pile HP 10 @ 42 Lbs./Ft		$ 22.71 Cwt	$25.57 Cwt	$30.26 Cwt	$31.60 Cwt	$27.41 Cwt	$30.40 Cwt					
40 Ft/Length												
Transportation Cost		$ 6.65 Cwt	$6.67 Cwt	$3.40 Cwt.	$3.53 Cwt	$ 6.67 Cwt	Included in price					
Total Cost Deli[illegible]ed		$404,484.	$443,849.	$469,733.	$485,310.	$469,486.						
Weight		1,377,600#	1,377,600#	1,377,600#	1,377,600#	1,377,600#	617,400#					
Routing		AC/CN/BCOL	CP/BCOL/ Kurstal Trucking	BCOL	BCOL	TBA FOB Ontario Frt.added	BCOL					
COUNTRY OF ORIGIN		Canada	Canada	Canada	Luxembourg	Canada	W. Germany UK &KOREA					
F.O.B. Wolverine												
SALES TAX Inc @5%												
TERMS Net 30 Days												
DELIVERY		3 Weeks	3 Weeks	3 Weeks	10 Weeks	3- 12 Weeks	3-8 DAys					

Recommended

TABULATION

1 of 2

INQUIRY No. P-49
REQ'N No. 89936
DATE OF INQUIRY Feb.24/83
CLOSING DATE, NOON Mar.9/83

F.O.B. Prince George

	QUANTITY AND DESCRIPTION		CANRON	EBCO IND. Main	(for later delivery) Alt	Q.M. MACHINERY	NORTHERN STEEL 'D' tolerance Main	increase tolerance to 2mm on position ½mm on size Alt	DOMINION BRIDGE	B.C.MILL MACHINERY	MAINLAND MACHINERY	INLET METAL	
			PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE
2117	Standard Footing Plates CSA 3/4" x 19-1/2 x												
	2'3 -1/2" per BCR dwg. A2/7-21466	$	41.28	43.31	39.90	47.94	44.26	41.40	44.75	44.44	45.27	47.45	
130	Portal Footing Plates												
	3/4" x 23-5/8" x 2'-3-1/2" per BCR Dwg.												
	A2/7-21466	$	52.58	53.03	50.40	55.98	56.75	50.15	53.50	54.35	55.21	57.50	
405	Rock Anchor Plate												
	3/4" x 23-5/8" x 2'-3-1/2" per BCR Dwg.												
	A2/7-21466 (Hole Tolerance - +/- 1 millimeter	$	50.72	52.50	49.61	55.77	53.69	50.15	53.50	54.35	54.17	57.45	
	Transportation to Prince George, BC	$	4,550.00	4,550.00	4,550.00	1,000.00	4,095.00	4,095.00	5,000.00	5,500.00	4,725.00	4,550.00	
	Total	$	119,317	124,394	115,662	132,353	126,915	118,569	128,358	128,657	129,678	135,744	
	Delivery Required: Vendor Delivery Partial: April 5/83 Balance: A.S.A.P.		Initial Shpt. as requested Balance 3 weeks	Initial Shpt. as requested Balance 2 weeks later	Initial Shpt. Apr.25/83 Balance 2 weeks later	May 1/83	Initial shipment as requested Balance 3 weeks later		1/3 of order April 15 Balance 2 weeks later	3 weeks ARO	6 weeks ARO for total shipment	Initial Shpt.5 wk ARO Balance TBA	
	Origin steel -		60% Cdn. 40%offshore	100% Canadian		100% Canadian	100% Canadian		100% Canadian	100% Canadian	100% Canadian	100% Canadian	
	Manufactured		Vancouver	Richmond, BC		Pr.George	Prince George		Vancouver	New West.	Abbotsford	N.Van.	
	Total-Weight (Tonnes)		161.6	157.7	157.7	157.3	157.5		157.7	158	157.5	159	

SALES TAX Inc.@ 5% →

TERMS Net 30 →

Routing via BCR →

INQUIRY NO. P-49

REQ'N. NO. 89936

DATE OF INQUIRY Feb.24/83

CLOSING DATE, NOON Mar.9/83

F.O.B. Prince George

QUANTITY AND DESCRIPTION		WELDCO LAST PRICE	ACO IND. PRICE	P.G. FABRICATING PRICE	BURRARD MECHANICAL PRICE	DAN CAN Main PRICE	(A 36 Plate) Alt PRICE	L.A. STEEL PRICE	LINDEN WELDING PRICE	PRICE	PRICE	PRICE
2117 Standard Footing Plates												
CSA 3/4" x 19-1/2 x 2'3-1/2" per BCR												
Dwg. A2/7-21466	$	47.40	48.80	51.00	50.35	55.45	46.23	60.32	65.75			
130 Portal Footing Plates												
3/4" x 23-5/8" x 2'-3-1/2" per BCR												
Dwg. A2/7-21466	$	57.98	54.55	63.00	60.00	65.61	55.59	72.30	75.14			
405 Rock Anchor Plate												
3/4" x 23-5/8" x 2'-3-1/2" per BCR												
Dwg. A2/7-21466 (Hole Tolerance - +/-1 mm	$	57.98	53.30	60.00	59.00	65.59	55.55	72.30	75.14			
Transportation to Prince George, BC	$	4,550.00	5.520.00	1,000.00	7,320.00	4,780.00	4,780.00	4,900.00	Inc			
Total	$	135,915	137,508	141,457	145,606	157,260	132,373	171,278	179,393			
Delivery Required: Vendor Delivery		As Requested	Initial Shpt.as Requested Balance	2-3 weeks ARO	As requested	Mid May	As Requested	May 20/83	As Requested			
Partial: April 5/83 Balance: A.S.A.P.												
Origin - steel		100% Canadian	100% Canadian	100% Canadian	100% Canadian	100% Canadian		100% Canadian	100% Canadian			
Manufactured Total Weight (Tonnes)		Vancouver 157.5	Vanc. 160	Pr.George 159	N.Vanc. 159.5	Vancouver 159.5		Surrey 159.6	Quesnel 157.8			
SALES TAX Inc. @ 5%		→										
TERMS Net 30		→			Progress Payments	→			Progress Payments			
Routing via BCR		→										

PORTALS

1. DESIGN DETAILS

1.1 The main components of each portal span are as detailed below:

Dwg. No. 2-503117 - End Structure V 4 or 5 metre lengths
Dwg. No. 2-503118 - End Structure H 4 or 5 metre lengths
Dwg. No. 2-503119 - Mid Structure 3 or 6 metre lengths

1.2 Combinations of these will produce portal spans of varying widths from 14 metres up to 22 metres in one metre increments. The mid-structures can also be made in 7 and 9 metre lengths for even greater variations in span widths. For the BC Rail Tumbler Ridge Branch Line, 17 metre spans sufficed for the majority of cases. A few 18 metre and 19 metre spans were added as required.

1.3 To assemble the structures into portal spans, two types of joint sets are required: Joint set number 90 as shown on Drawing No. 4-503082 and Joint set number 97 as shown on Drawing No. 4-503091. The components for which are shown on Drawing Nos. 4-503083, 4-503084, 3-503085 and 4-503092, 4-503093, 3-503094 respectively. The use of these joint sets in assembling the portal spans is shown on Drawing Nos. 3-503260, 3-503261 and 3-503262.

1.4 To mount the portal spans onto the poles (C250 x 30), two types of brackets and some mounting hardware (J-bolts, etc.) are required. The brackets are as shown on Drawing Nos. 3-503107 and 3-503108 which are used as shown on Drawing No. 3-503267 to secure the portal spans to the poles.

2. SOURCING AND COST SUMMARY

2.1 The material was tendered on January 20, 1983 with a closing date of February 7, 1983. A total of 23 firms responded, and the lowest 14 are tabulated on page 5-15 of this appendix.

The summary below is based on the responses from the fourteen lowest bids:

ITEM	HIGH	LOW	AVERAGE	CONTRACTED
4 m End Structure V	$565.00	$333.70	$433.25	$333.70
5 m End Strucutre V	(See note 1 below)			517.83
4 m End Structure H	562.00	320.21	431.52	320.21
5 m End Structure H	834.00	435.68	546.83	504.33
3 m Int. Structure	359.00	249.20	323.07	249.70
6 m Int. Structure	743.40	457.92	586.56	457.92
Joint Set No. 90	27.00	12.60	19.48	22.53
Joint Set No. 97	27.00	12.60	19.60	22.53
Mounting Console	36.65	18.60	27.13	29.86
Mounting Crossbar	17.00	6.51	13.32	15.67
Mounting Hardware	(See note 2 below)			
Total Order	$159,597	$93,500	$121,759	$153,707

Note 1: The requirement for the 5 metre end Structure V was established subsequent to the award of contract for the other items, and its purchase was directed to the same contractor.

Note 2: Mounting hardware such as J-bolts, 3/4" UNC x 8" bolts, special attachments, etc. were procured separately and the cost per portal installation amounts to $307.86.

2.2 The cost of each portal assembly, complete with mounting hardware, therefore, varies as follows for the standard 17 metre span.

	HIGH	LOW	AVERAGE	CONTRACTED
ea 1 4 m End V	$ 565.00	$ 333.70	$ 433.25	$ 333.70
ea 1 4 m End H	562.00	320.21	431.52	320.21
ea 1 3 m Int.	359.00	249.20	323.07	249.70
ea 1 6 m Int.	743.40	457.92	586.56	457.92
ea 6 No. 90 Joints	162.00	75.60	116.88	135.18
ea 6 No. 97 Joints	162.00	75.60	117.60	135.18
ea 4 Portal Mounts	146.60	74.40	108.52	115.44

ea 2 Portal Crossbars	34.00	13.02	26.64	31.34
*Mounting Hardware	540.53	307.86	474.20	307.86
Total	$3,274.13	$1,907.51	$2,618.24	$2,090.53

*Mounting Hardware cost variation based on variation in overall cost of nuts and bolts as discussed in Appendix 6.

2.3 The cost of 18 metre spans will, therefore, vary as follows:

	HIGH	LOW	AVERAGE	CONTRACTED
17 metre cost	$3,274.13	$1,907.57	$2,618.24	$2,090.53
- ea 1 4 m End H	- 562.00	- 320.61	- 431.52	- 320.21
- ea 1 5 m End H	834.00	435.68	546.83	504.33
Total	$3,546.13	$2,022.98	$2,733.55	$2,274.65

2.4 The cost of 19 metre spans will likewise vary as follows:

	HIGH	LOW	AVERAGE	CONTRACTED
18 metre cost	$3,546.13	$2,022.98	$2,733.55	$2,274.65
- ea 1 4 m End V	- 565.00	- 333.70	- 433.25	- 333.70
- ea 1 5 m End V *	856.32	447.34	561.46	517.83
Total	$3,837.45	$2,136.62	$2,861.76	$2,458.78

* Assumes End V costs vary as per End H costs.

Summary of Bids - Portals

PORTAL STRUCTURES

Inquiry Date: Jan. 20/83
Closing Date: Feb. 7/83

Item Description	Qty.	L.A. Steel	DANCAN	EBCo	Northern Steel	Mainline Machinery	P.G. Fab. & Eng.	Burrard Mech.	CANRON	XL Iron Works	Wilson Steel	N & M Custom Welding	B.C. Mill Machinery	Dominion Bridge	West. Dom. Steel
Joint Set 90	215	22.53	18.67	19.00	16.41	18.62	17.82	20.62	23.73	19.07	21.62	17.32	17.77	12.60	27.00
Joint Set 97	215	22.53	18.67	19.00	16.41	18.62	17.82	22.25	23.73	19.07	21.62	17.32	17.77	12.60	27.00
Mounting Console	280	28.86	26.03	23.50	25.65	25.34	27.63	32.06	36.65	29.79	28.17	18.90	24.69	18.60	33.00
Mounting Bracket	280	15.67	13.31	10.50	13.50	13.39	15.37	6.51	16.71	14.42	15.96	10.50	13.94	9.80	17.00
Freight Cost	Lot	302.00	651.00	767.00	Inc.	1,376	Inc.	Inc.	Inc.	Inc.	Inc.	3,632	Inc.	Inc.	Inc.
Sub-total		22,738	19,694	18,457	18,018	20,227	19,702	20,017	25,145	20,579	21,653	19,312	18,458	13,370	25,610
4 m End V	67	333.70	376.36	351.00	381.87	415.67	430.00	406.75	414.42	473.58	431.05	466.56	509.53	565.00	510.00
4 m End H	64	320.21	376.36	357.00	381.16	404.70	433.00	406.75	413.46	477.14	430.25	466.52	499.71	562.00	513.00
5 m End H	3	504.33	435.68	450.00	559.33	506.38	535.00	527.00	497.46	533.00	538.33	589.57	522.33	834.00	623.00
3 m Intermediate	67	249.70	275.83	298.00	279.25	311.52	359.00	330.40	322.11	319.67	346.87	371.57	367.10	334.00	348.00
6 m Intermediate	67	457.92	472.02	522.00	499.15	618.27	547.00	614.92	601.67	613.82	618.80	743.40	576.91	630.00	696.00
Freight Cost	Lot	1,726	4,372	4,168	Inc.	5,257	Inc.	Inc.	Inc.	Inc.	Inc.	22,006	Inc.	Inc.	Inc.
Sub-Total		93,501	105,088	101,690	103,810	125,822	118,829	118,202	118,284	126,410	122,733	159,592	130,936	140,913	138,819
Pole Extenion	50	111.42	84.80	138.00	120.67	146.25	151.00	135.00	157.54	107.02	172.04	105.00	213.84	156.00	112.00
Freight Cost	Lot	50.00	165.00	272.00	Inc.	514.00	Inc.	Inc.	Inc.	Inc.	Inc.	1,364	Inc.	Inc.	Inc.
Sub-Total		5,621	4,905	7,172	6,031	7,826	7,550	6,750	7,877	2,351	8,602	6,614	10,692	7,800	5,600
GRAND TOTAL		121,860	129,187	127,319	127,860	153,876	146,081	144,968	151,306	152,340	162,988	185,523	160,085	162,083	170,029

APPENDIX 6

MECHANICAL COMPONENT AND ASSEMBLIES

SPECIAL CASTINGS AND FABRICATIONS
INSULATORS
CANTILEVER TUBING
MISCELLANEOUS HARDWARE
NUTS AND BOLTS
WIRE ROPE
TUNNEL OCS SUPPORT HARDWARE

SPECIAL CASTINGS AND FABRICATIONS

DESIGN DETAILS

The overhead contact system components were specified in "Specification for Overhead Line Equipment Hardware for British Columbia Railway Tumbler Ridge Branch Line 50 kV Electrification" dated December 22, 1982, a copy of which is included in Volume II of this report. The material specified therein was identified in various packages of clearly defined sets of components to ensure proper fit of mating components. The seventy-five components listed below require special castings or fabrication, and these were tendered separately.

DRAWING NUMBER	COMPONENT
4-503045 *	Support loop for dropper
3-503046	Steering ring for tensioning weights
3-503048 *	Tube link for 27 mm tube
4-503049 *	Clevis joint for cantilever
3-503050 *	Tube socket for 55 mm tube
3-503051 *	Tube fitting for cantilever with 54 or 55 mm tube
4-503053	Top-tie for cantilever
4-503054	Tensioning counter weight suspension rod
3-503055	Link
3-503056 *	Wedge clamp for stranded flexible or 35 mm^2 wire
3-503057	Tensioning pulley fork
4-503061	Pin 19 x 100
4-503062	Pin 19 x 54
4-503063	Tensioning pulley axle
3-503064	Square pole - portal cantilevers
3-503065 *	Cross link for tensioning equipment
3-503066	Tensioning link
3-503067 *	Pulley for weight tensioning
4-503069	Link
4-503073	Back plate

DRAWING NUMBER	COMPONENT
3-503076 *	Clamp for 2 wires in messenger wire channel
4-503077	Tensioning link
2-503078	Tensioning balance
3-503081 *	Wedge clamp for 107 mm^2 contact wire, 70 mm^2 and 50 mm2 wires
4-503090	Retainer pin
3-503111 *	Tensioning counter weight - 22 kg
3-503112 *	Socket for contact wire clamp
3-503113 *	Socket for contact wire clamp
3-503114 *	Socket for contact wire clamp
4-504115	Hex bolt - 1/2 - 13 UNC SAE Gr. 8
4-503121	Bracket insert for 42 mm tube
4-503122 *	Messenger wire channel for 70 mm^2 wire
3-503124 *	Clamp for messenger support 70 mm^2 wire
2-503125 *	Hinge for cantilever bracket
4-503127	U-bolt with nuts for 42 mm tube
2-503128 *	Cantilever pivot bracket
3-503130	Bracket for suspension of earth wire
2-503131	Mounting beam for twin arm cantilever
3-503132 *	Hinge holder
3-503133	Mounting beam for common automatic tensioning
3-503134	Lower bracket for guide tube
4-503135	Upper bracket for guide tube
4-503136 *	Head of attachment assembly
4-503138	Tensioning holder
4-503139	Tensioning holder
3-503140 *	Steady arm
3-503144 *	Catenary hanger
4-503416	Square pole mounting bar
3-503419	Bracket for feeder wire insulator
3-503421 *	Tube link for 42 mm tube
3-503422 *	Clevis link
3-503424 *	Tube connector for 42 mm tube
3-503429	Extension bracket for mounting of earth wire

4-503570	Hinge bracket
3-503571	Spacer - 1000 mm
4-503574	Bracket for feeder wire insulator at portal structure
4-503575	Angle bar for square pole mounting
3-503576	Bracket for pulley fork
3-503577 *	Pulley fork
3-503578 *	Pulley
3-503580 *	Head of attachment
4-503581	Attachment for steady arm
4-503584	Washer, part no. 04-13-090-2
3-503657	Mounting beam for common automatic tensioning
3-503670	Spacer - 1700 mm
4-503674	Attachment for registration support
3-503675	Registration support
3-503776 *	Clevis link
4-503780	Grounding wire bracket

Components which required castings are marked with an *.

The material was tendered on January 25, 1983 with a closing date of February 28, 1983. A total of ten firms responded. Only seven of the ten responded with complete bids.

The following is a summary based on the complete bids: (see the specification for more details on the contents of each package)

	HIGH	LOW	AVERAGE	CONTRACTED
Package No. 1	$ 340,613	$115,338	$ 190,707	$143,506
Package No. 2, 10 & 11	547,023	204,848	326,369	216,183
Package No. 5	936,165	536,079	693,855	536,079
Package No. 7	72,735	20,714	36,358	31,578
Package No. 8	18,901	5,876	10,457	9,575
Package No. 9	21,868	13,002	15,794	13,712
Total	$1,831,293	$950,633	$1,270,793	$950,633
Pattern & die costs	103,622	91,952	112,602	97,106

The contract was awarded to the firm with the lowest total cost, in this case to EBCO Industries Ltd. Total value of the order was $1,049,149.00. Unit costs for major assemblies (cantilevers, weight tensioning units, mid-point anchors, etc) have been derived from the costs of the components and sets as contracted.

SET NUMBER	QUANTITY	COST PER SET
1	2,733	$13.34
2	2,720	12.27
3, 3a, 3b	2,942	26.95
4	4,086	22.41
5	2,348	12.02
5a	581	18.52
6	1,500	17.99
6a	55	32.07
7	460	16.09
8	193	17.07
9	40	43.53
10	630	40.72
11	20	15.81
12	186	16.68
12a	330	8.86
13	275	8.39
14	92	106.52
15	20	21.70
16	(Procured elsewhere)	
17	280	12.65
18	5	7.60
19	(Procured elsewhere)	
20	600	$104.34
21	300	89.07
22	310	17.77
23	304	26.45
24	300	27.51
25	300	11.64
26/28	300	18.00
27/29	300	17.30

30	280	43.25
31	324	12.13
32	300	17.79
33	20	20.91
34	43	30.77
35	20	25.60
36	2,632	12.34
37	12,400	30.00

DRAWING NO.	DESCRIPTION	QUANTITY	COST PER SET
3-503140	Steady arm	360	$ 29.41
4-503570	Hinge bracket	300	8.67
4-503416	Holder	50	9.36
4-503581	Attachment	40	13.70
4-503674	Attachment	25	83.63
4-503675	Support	25	108.88
4-503073	Back plate	176	1.81
3-503571	Bar	153	8.12
3-503670	Bar	30	10.50
3-503576	Bracket	10	18.00
3-503577	Pulley fork	250	16.55
3-503578	Pulley	45	64.90
4-503061	Tube pin	20	3.71
4-503780	Grounding brackets	625	4.01
3-503580	Head of attachments	1,300	2.89
3-503422	Clevis link	130	6.23
4-503062	Pin	40	1.55
4-503115	Bolt	100	.50
4-503090	Pin	200	.15
4-503136	Head of attachment	300	3.97
3-503081	Wedge clamp	150	9.66

INQUIRY NO. P-16

REQ'N. NO.

DATE OF INQUIRY January 25, 1983

CLOSING DATE/HOUR Feb.28/83

F.O.B. Prince George

Catenary Hardware per British Columbia Railway Drawings
· includes Cast and Fabricated Components, Assembled.

	COMPLETE BIDS							PARTIAL BIDS			
	ESCO IND	MALKIN & PINTON	WELDCO	LISTER BOLT & CHAIN	JOSLYN IND.	SLACAN	B C MILL MACHINERY	TRYDOR ENG.	DOMINION BRIDGE	PATTON & COOKE	ROBAR IND.
QUANTITY AND DESCRIPTION	LAST PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE
Package No. 1	$143,506	$152,811	$212,551	$209,834	$161,455	$115,338	$340,613	$189,551	NQ	NQ	
Package No. 2, 10 and 11	$216,183	$306,054	$229,100	$320,760	$253,079	$373,995	$547,023	$314,763	$204,848	$497,887	
Package No. 5	$536,079	$570,191	$614,357	$593,338	$767,338	$936,165	$843,140	$690,234	NQ	NQ	
Package No. 7	$ 31,578	$ 41,368	$ 20,714	$ 24,120	$ 44,207	$ 31,372	$ 72,735	$ 33,840	$ 27,284	NQ	
Package No. 8	$ 9,575	$ 5,876	$ 7,407	$ 11,486	$ 8,822	$ 18,901	$ 11,132	NQ	NQ	NQ	
Package No. 9	$ 13,712	$ 15,565	$ 13,055	$ 21,868	$ 16,670	$ 15,828	$ 16,650	$ 13,002	NQ	NQ	
SUB TOTAL	$950,633	$1,091,865	$1,097,184	$1,181,406	$1,251,571	$1,491,599	$1,831,293				
Pattern and Die Cost (Not Inc. in Above prices)	$ 57,106	$ 94,483	$103,622	$101,149	*$ 61,817	$107,302	$ 91,952	$ 84,881	$ 28,842	$ 22,279	$ 91,952
Castings Only Cost (Inc. In Above prices)	($551,250)	not shown	not shown	not shown	not shown	not shown	not shown	not shown	not shown	not shown	$526,475 *
GRAND TOTAL DELVD.	$1,847,739	$1,186,348	$1,200,806	$1,282,555	$1,313,388	$1,678,901	$1,923,245				
Routing	BCR	BCR	BCR	BCR	TBA	CPR	BCR	BCR	TRUCK	BCR	N/A
Total Weight In Pounds	935,300#	907,356#	865,861#	869,963#	916,430#	933,915#	928,000#	866,400#	155,000#	141,580#	709,244
Delivery: Leadtime To Start Up	5-6 wks	7 wks	8 wks	8 wks	16-20 wks	15 wks	6 wks	TBA	16 wks	10 wks	3 wks
Rate of Production	100,000# per wk	TBA	TBA	TBA	TBA	95,000# per wk	TBA	TBA	25,000# per wk	TBA	120,000# per wk
Terms of Payment	Net 30	Net 15 N.P.	Net 30	Net 30	Net 30	Net 30	Progress Payments	Progress Payments	Net 30	To Be Negotiated	Net 15 5-20 Dys
Origin	Richmond BC	Surrey BC	Richmond BC	Richmond BC	Toronto ONT	Hamilton ONT	New West. BC	Vancouver BC	Winnipeg MAN	Surrey BC	Surrey BC
COMMENTS:	Union Shop will only accept 100% order or BCR to supply Castings				*Retains Ownership of ? Patterns & Dies	Will only accept 100% order	* Incomplete missing 2 parts				* FRT Added to Quote
F.O.B.	Prince George	Prince George	Prince George	Prince George	Prince George	Prince George	Prince George	Prince George	Prince George	Prince George	Surrey BC *
SALES TAX @ 5%	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.
TERMS											

INSULATORS

The specification for insulators is included in Volume II of this report. The specification covered the following insulators: (drawings are included in Volume II of this report)

a) Dwg. No. 2-503149 Rod Insulator
b) Dwg. No. 2-503150 Rod Insulator
c) Dwg. No. 2-503272 Rod Insulator
d) OB No. 32439 or Equal Suspension Insulator (string of 5)
e) OB No. 231006 or Equal Station Post Type Insulator
f) OB No. 48539 or Equal Line Post Type Insulator

Subsequent to the preparation of the specification, the requirement for the Rod Insulators at item (a) above (Dwg. No. 2-503149) was deleted.

Item (b)	is the upper insulator on a standard cantilever.
Item (c)	is the lower insulator on a standard cantilever. It can also be used as the upper insulator when the top-tie is replaced with a 42 mm tube.
Item (d)	is used for terminating contact wires, messenger wires and feeder wires.
Item (e)	is used for cantilevers in tunnels.
Item (f)	is used for the feeder wire and is supplied c/w a clamp equivalent to OB No. 270661.

The material was tendered in November 1982 and seven firms responded. Only four of the seven responded in total (see page 6-9 for a summary of the responses. A comparison of the responses is as follows:

ITEM	QTY	HIGH	LOW	AVERAGE	CONTRACTED
b	3,190	$209.30	$ 71.10	$121.00	$ 71.10
c	3,190	147.70	54.68	114.98	68.55
d	693	92.85	59.50	75.83	59.50
e	412	220.50	95.75	140.93	95.75
f	1,580	125.95	103.54	111.06	103.54

Suppliers for Item (f) is OB Canada. Supplier for Items (b), (c), (d) and (e) is NGK.

Subsequent to the order being placed, two additional items were added to the requirement as follows:

ITEM	DESCRIPTION	QUANTITY	PRICE
g	OB No. 43980 Insulator c/w clamp	110	$97.67 ea.
h	OB No. 87583 Stud	1,690	7.82 ea.

Item (g) is the insulator used to support the feeder wire through portal structures.

Item (h) is the stud required to secure items (f) and (g) to their respective mounting fixutres.

Both items were procured direct from OB Canada at the prices indicated.

Note that Item d (total value $41,234) has been considered, by arbitrary definition, as part of the electrical components and assemblies category.

The total value of insulators excluding the suspension insulators is therefore $679,010.20.

INSULATORS

Inquiry Closing Date
December 17, 1982

Item	Quantity	NGK	CEGELEC	OHIO BRASS	JOSLYN	ROSENTHAL	SIEMENS	NELSON MACHINERY
A. Rod insulator per dwg. no. 2-503149	200	75.05	94.00	152.62	225.75	83.80	162.45	NQ
B. Rod insulator per dwg. no. 2-503150	2,900	71.10	76.00	145.27	209.30	76.65	147.70	NQ
C. Rod insulator per dwg. no. 2-503272	2,900	68.55	85.00	141.07	192.85	54.68	147.70	NQ
D. Suspension insulator - clevis type O.B. 32439 or equal (string of 5)	400	59.50	71.50	75.55	74.75	NQ	NQ	92.85
E. Stn. post insulator O.B. 231006 or equal	375	95.75	110.00	104.65	220.50	NQ	NQ	173.75
F. Line post insulator O.B. 48539 or equal	1,500	116.30	105.23	103.54	125.95	NQ	NQ	104.30
Transportation to Prince George		7,527.00	Inc.	62,120.00	175,500.00	Extra	7,000.00	3,018.00
TOTAL		661,678	690,515	1,137,304	1,664,478	-	-	-

CANTILEVER TUBING

DRAWING DETAILS

Cantilever assembly drawings are included in Volume III of this report. In particular, the following assembly drawings apply:

DRAWING NUMBER	TITLE
3-503287	Simple Cantilever
2-503288	Twin-arm cantilever for overlap span
2-503289	Twin-arm cantilever for switch
3-503415	Cantilever on inner curve R - 291 - 388 m
2-503418	Twin-arm cantilever with electric section for switches
3-503579	Single cantilever at mid-point anchor
3-503661	Cantilever for Parsnip River Bridge Type A
3-503662	Cantilever for Parsnip River Bridge Type B

All of the above cantilevers utilize varying lengths of some or all of the following sizes of tubes:

55 mm
44 mm
27 mm

The length of tubing required, as well as the length of top-tie (Dwg. No. 4-503053, see Volume III), is determined from the cantilever set numbers which are called out on the site specific layout drawings. The tube lengths required for each set number are shown in the following drawings:

DRAWING NUMBER	TITLE
3-503433	For single cantilevers
3-503434	For single cantilver used on inner curves (R - 291 - 388 m) and mid-point anchors
3-503436	Twin-arm cantilever type C & D per dwg. 2-503288

3-503437	Twin-arm cantilever type E & F per dwg. 2-503288
3-503438	Twin-arm cantilver for switches
3-503439	Twin-arm cantilever with electric section for switches

SOURCING

The specification for the tubing is included in Volume II of this report. The material specified is not readily available in Canada and the response from Canadian firms was extremely limited (see next page for summary of responses). The 55 mm tubing was procured from EBCO Industries Ltd. of Richmond, B.C. in uniform lengths of 5.9 metres at a price of $8.24 per metre. The 42 mm tubing and 27 mm tubing was unavailable without special mill runs and the quantity required did not warrant a special run. The 42 mm and 27 mm tubing was therefore obtained from Europe by direct procurement from Wirsbo Bruks AB of Sweden in uniform lengths of 6.4 metres at a price of $3.06 per meter for the 42 mm tubing and $2.05 per metre for the 27 mm tubing (F.O.B. Vancouver).

Total order cost of the 55 mm tubing was $78,855.30.

Total order cost of the 42 mm and 27 mm tubing was $23,636.15.

The cutting of the tubes to the required lengths was arranged through firms close to the BC Rail warehouse in Prince George; specifically, P.G. Fabricating for the 55 mm tubing ($1,300) and Northern Steel for the 27 and 42 mm tubing ($3,500).

It will be noted from the design drawings that the 42 mm tubing is also used in the weight tensioning assemblies (see Dwg. No. 2-503285, for example). Each weight tensioning unit uses a 4.5 metre length of 42 mm tubing as a guide tube for the counterweight assembly. A standard 1-1/4" galvanized iron pipe was procurred for this purpose for a total order value of $3,229.50 for 150 pieces cut to length and delivered. The total cost of tubing was, therefore, $110,520.95.

TABULATION

Galvanized Steel
Tubing CSA #G40.21M81,
CAN 3-G40.20M81 & CSA
G164-M1984

Prices/metre

Qty.	Size	Interprovincial Pipe	Ebco	Stelco
		Galv. Steel to Spec.	Galv. Steel to Spec.	G40.21 m Class h Gr. 350 w Black Bare Steel not to Spec.
9000 metres	55 mm x 4 mm	60.3 mm x 4 mm $6.1771	54 mm x 3.76 mm $7.9782	60.3 x 4.78 mm $5.387
2400	42 mm x 4 mm	42.2 mm x 4 mm $4.3543	41.3 mm x 3.4 mm $5.826 (min. order Qty. 5700 m)	42.2 mm x 3.18 mm $2.6565
5500 metres	27 mm x 3.6 mm	26.7 mm x 3.6 mm $2.3677	26.9 mm x 2.41 mm $2.8435 (min. order Qty. 12,450 m)	26.7 mm x 3.18 mm $1.533
	Subtotal	$79,066.57	$140,418.58	$63,285.60
	Freight	$ 2,400.00	$ 3,400.00	$ 2,400.00
		$81,466.57	$143,813.58	$65,685.60
FOB Point		Prince George	Prince George	Vancouver (Frt. added to Pr. George)
Sales Tax		Inc.	Inc.	Inc.
Terms		Net 30	Net 30	Net 30
Delivery		6 weeks ARO	13 weeks ARO	8 weeks ARO
Origin		Port Moody, BC	Woodstock, On	Hamilton, ON

MISCELLANEOUS HARDWARE

Several items of standard, off-the-shelf hardware such as guy rods anchors, exothermic connectors, etc., were required. The bulk of these were specified in a separate specification (see Volume II of this report). Others were specified as the need was identified.

The following items were procured from NEDCO Ltd. of North Vancouver. Many are substitutes with equivalence to the items listed in the specification.

ITEM		DESCRIPTION	QTY	UNIT PRICE
1	62401	Slacan Plate Anchor	850	$ 20.21 ea
2	8418	Slacan Anchor Rod	850	7.46 ea
3	22237H	Slacan Clevis Dead End	850	4.35 ea
4	14055	Slacan Guying	1,700	1.56 ea
5	63472	Slacan Plastic Guard	100	3.81 ea
6	PBW-T20-2C	Erico Welder	42	164.04 ea
7	PBW-2C	Erico Mould	42	74.30 ea
8	PB 65	Erico Weld Metal (50/box)	2,100	94.95 C
9	PBC105C	Erico Clamp	6	80.26 ea
10	T320	Erico Igniter	6	5.70 ea
11	PBS05F	Erico Sleeve	2,100	30.65 C
12	PBW-D80	Erico Die	6	30.75 ea
13	22181	Slacan Rock Anchor	150	9.05 ea
14	7544	Slacan Rock Anchor Extension	75	15.29 ea
15	KVS28	Burndy Clips	120	6.13 ea
16	22133	Slacan Strain Clamp	10	12.30
17	22361	Slacan Saddle Clamp	300	5.95 ea
TOTAL COST DELIVERED				$48,746.41
Added		Self-locking tie wraps TYS-8 T&B	2,500	61.35 C
Total addition				$ 1,533.75

It should be noted that $13,348.56 of the total is require for exothermic devices which are installation materials.

The following items were procured from the Kupler Corporation:

ITEM		DESCRIPTION	QTY	PRICE
1	302-776-909	Pfisterer Flex clamp	330	$ 5.69
2	302-381-381	Pfisterer Connector	800	3.99
3	302-537-537	Pfisterer Connector	100	21.06
Total order		$7,175.70		

The following items were procured from Ohio Brass Canada Inc.

ITEM		DESCRIPTION	QTY	PRICE
1	84289	OB Galvanized clamp	670	$18.59
2	16907	OB Galvanized clamp	20	29.47
3	10572	OB Galvanized eye	20	14.98
4	15972	Trolley wire deadend clamp	35	65.34
5	79608	OB Shackle	65	8.90
6	82860	OB Galvanized clamp	406	10.76
Total order		$20,034.30		

The following were procured direct from EBCO Industries:

ITEM	DESCRIPTION	QTY
1	UL Type Spring clips for C130 x 10 Channels	1,110
2	UL Type Spring clips for C130 x 13 Channels	925
3	UL Type Spring clips for C150 x 16 Channels	300
4	UL Type Spring clips for C250 x 30 Channels	150
Total order cost	$2,047.00	

Total order cost for miscellaneous hardware is, therefore, $79,537.16.

NUTS AND BOLTS

A separate specification was prepared to cover special and standard bolts and nuts (see Volume II of this report). The material specified was tendered in March 1983 and only two complete quotations were received:

Malkin & Pinton, total lot price	$138,576.00
Lister Bolt & Chain, total lot price	$243,305.00

The order was placed with Malkin & Pinton for the following items:

ITEM	DESCRIPTION	QTY	PRICE
1	04-14-002-6 Hookscrew per dwg. 4-503109	11,000	$264.50 C
2	04-14-001-8 Hookscrew per dwg. 4-503109	11,000	259.23 C
3	04-14-003-4 Hookscrew per dwg. 4-503109	2,900	269.89 C
4	04-14-012-5 Hookscrew per dwg. 4-503109	250	756.13 C
5	3/4" UNC x 7" Bolt c/w nut & 2-1/2" O.D. Washer	2,250	195.93 C
6	3/4" UNC x 3-1/4" Bolt c/w nut and 2-1/2" O.D. Washer	60	150.95 C
7	3/4" UNC x 12" Bolt c/w nut and 2-1/2" O.D. Washer	200	421.66 C
8	3/4" UNC x 5-1/2" Bolt c/w nut and 2-1/2" O.D. Washer	650	172.09 C
9	3/4" UNC x 1-3/4" Bolt c/w nut and 2-1/2" O.D. Washer	900	134.07 C
10	1/2" UNC x 1-1/2" Bolt c/w nut and 2-1/2" O.D. Washer	300	94.29 C
11	M20 x 45 Bolt c/w nut and 20 x 3 x 63 Washer	300	145.20 C
12	3/4" UNC x 8" Bolt nut and 2-1/2" O.D. Washer	300	219.06 C
13	M20 x 50 bolt c/w wax nut per dwg. 4-503095	10,000	96.20 C
14	1/2" UNC x 2" Bolt c/w nut and lockwasher	4,100	29.13 C

15	1/2" UNC x 6" Bolt c/w nut and lockwasher	1,300	60.04 C
16	875 U-bolt per dwg. 3032-6-4001	375	370.80 C
17	Hex nut with washer for 1" bolt	800	47.39 C
18	1" x 2-1/2" botl c/w nut and lockwasher	40	189.72 C
19	3/4" x 2'-0" anchor bolt	9	869.00 C
20	1/2" x 2'-0" anchor bolt	520	318.00 C
21	1-1/2" x 4-3/4" Bolt, nuts and washers	517	769.78 C
22	1-1/4" x 4-1/2" Bolt, nuts and washers	8,475	507.58 C
23	1-1/2" I.D. Lockwashers	517	56.26 C
24	1-1/4" I.D. Lockwashers	8,475	33.79 C

Total Order $142,457.75

An additional item was ordered from Industrial Fasteners Ltd. as follows:

Grade 5 Hex bolt 1/2" x 13 thread, 1" long with 3/4" thread and lockwasher	2,700	21.12 C

Total Order $ 570.24

With the exception of items 21 through 24, the purpose of nuts and bolts is as explained in the specifications. Items 21 through 24 are used on the pole foundations for mounting the poles. The additional item procured from Industrial Fasteners is used to secure the tunnel cantilever insulators to the support hardware.

WIRE ROPE

The wire rope required to suspend the counterweights was specified and procured as a separate package. The specification (included in Volume II) covered the design, manufacture and supply of stainless steel wire rope shown as Item 8 on the weight tensioning assembly drawing numbers 2-503285 and 2-503656. The material required was 300 lengths of 10 mm diameter rope grade AISI 316 stainless steel wire rope pre-cut to 7.2 metre lengths with both ends tapered and fused.

The material was tendered in February 1983 and six firms responded as shown on the following page. Their quotations varied as follows:

	HIGH	LOW	AVERAGE	CONTRACTED
7.2 m lengths	$146.00	$ 26.68	$ 74.14	$ 39.13
Total order	$43,800.00	$8,134.00	$22,285.00	$11,739.00

The contract was awarded to the Greening Donald Company Ltd. based on the best combination of price and delivery for a total order value of $11,739.00.

TABULATION

INQUIRY NO. P30

REQN NO.

DATE OF INQUIRY FEBRUARY 1/83

CLOSING DATE REQ'N FEB. 25/83

F.O.B. PRINCE GEORGE, B.C.

QUANTITY AND DESCRIPTION	GUNNEBO BRUKS SWEDEN	GREENING DONALD RICHMOND BC	COMOR SUPPLIES SURREY, BC	BC WIRE ROPE RICH. BC	WESCO INDUSTRIES VANCOUVER BC	WESTERN INDUST. SUPPLY VAN. BC					
	LAST PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	P
300 LENGTHS 12 X 6 x 3 x 24 STAINLESS STEEL	TO Spec.	19 x 7 Non-rotating	18 x 7FC Non-rotating	(302) 19 x 7 Non-rotating	19 x 7 Non-rotating	To Spec.					
10 mm WIRE ROPE GRADE											
AISI 316/ 7.2m/ Len.	$26.68	$39.13	$41.50	$92.98	$98.54	$146.00					
WEIGHT EST.	1,806 #	1,806 #	Not Shown	Not Shown	Not Shown	Not Shown					
TRANSPORTATION COST	$130.00	Incl.	$130.20	Incl.	$19.45	Incl.					
TOTAL COST DELIVERED	$8,134	$11,739	$12,580.20	$27,894	$29,562	$43,800					
	* Against Letter of Credit										
COUNTRY OF ORIGIN	SWEDEN	CANADA	JAPAN	U.S.A.	U.S.A.	U.S.A.					
F.O.B.	VCR. BC	PRINCE GEORGE	PRINCE GEORGE	PRINCE GEORGE	VCR. BC	PRINCE GEORGE					
SALES TAX @ 5%	INCL.	INCL.	INCL.	INCL.	INCL.	INCL.					
TERMS	*	NET 30	NET 30	NET 30	NET 30	NET 30					
DELIVERY	10 WEEKS	6-7 WKS	14 WKS	7-10 WKS	11 WKS	9 WKS					

TUNNEL HARDWARE

The fabrication, supply and delivery of various steel members which were unique to the overhead contact system in the tunnels was detailed in a separate specification (see Volume II of this report).

The required material was tendered in March 1983 along with a few items required outside the tunnels, eg. surge arrestor mounting hardware.

Bids were received from eleven firms and their responses are tabulated at page 6-20 of this appendix. The following provides an overview of the quotations:

ITEM	HIGH	LOW	AVERAGE	CONTRACTED
No. 871 Circular plate	$ 7.25	$ 3.21	$ 4.95	$ 3.21
No. 872 Pipe 6" x 20'	320.00	148.60	209.60	189.46
No. 877 Clamp spacer	17.88	7.36	11.00	7.91
No. 880 Support tee	118.00	64.10	83.42	67.90
No. 879 Support tee	112.75	59.27	86.77	59.27
No. 881 Support channel	579.31	211.33	292.98	211.33
No. 882 Support channel	153.31	59.50	96.93	59.50
No. 888 Anchor bracket	37.00	9.34	21.47	16.63
No. 895 Taper washer	15.01	5.25	10.29	9.39
No. 896 Strain Strap	12.06	5.40	7.52	8.20
No. 990 Square Plate	14.50	3.62	6.07	4.05
3-503782 Knuckle	89.25	13.04	29.72	27.25
3-503658 Pulley bracket	121.15	15.08	38.02	32.78
4-504154 Angle bar	30.87	9.98	17.57	15.52
3-504156 Platform	395.46	94.42	130.76	95.00
Total Order	$260,340	$153,550	$196,921	$153,500

Subsequent to bids being offered, adjustments were made to the quotations of some items and two new items listed below were added:

Dead end ties - 12 at $28.35 each

No. 1007 Messenger wire spacer - 110 at $29.25 each

The total revised value of the order was $92,208.70 which was placed with Inlet Metal.

INQUIRY NO. P-59
REQN NO. 89950
DATE OF INQUIRY
CLOSING DATE NOON April 8, 1983

F.O.B. PRINCE GEORGE

* Alt. material

QUANTITY AND DESCRIPTION	INLET A	INLET B	NORTHERN STEEL	MALKIN AND PINTON	EDCO	WELDCO	BURRARD MECH.	B.C. MILL	CANRON	PATTON AND COOKE	DOMINION BRIDGE	JOSLYN
	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE
750 only #871 Circular Plates	3.21	3.21	3.06	4.08	5.35	5.17	5.48	5.77	5.70	6.30	4.01	7.25
425 only #872 Standoff Steel Pipe in (8,500 ft) Standard lengths 18-23 ft.	189.46	189.46	160.37	148.60	193.00	168.81	177.14	199.50	185.32	320.00	110.59	273.00
325 only #877 Messenger Clamp Spacer	7.91	7.91	8.37	9.86	7.56	11.34	7.36	14.98	17.88	12.00	11.65	15.14
10 only #880 Registration Support Tee (curve)	67.90	67.90	64.10	66.49	81.90	81.10	88.00	81.30	82.20	118.00	115.00	87.03
340 only #879 Registration Support Tee (tangent)	59.27	59.27	65.39	99.12	74.70	102.47	104.41	88.50	112.75	111.00	64.50	99.84
30 only #881 Insulator Support Channel (cavernous)	301.85	* 211.33	275.83	270.04	288.50	263.90	343.00	317.30	336.00	362.00	266.77	579.31
375 only #882 Insulator Support Channel	80.47	* 59.50	76.19	81.13	75.75	93.86	91.72	90.17	158.12	107.00	95.95	153.31
115 only #888 Anchor Bracket	16.63	16.63	26.23	11.98	13.28	12.09	18.45	35.55	37.00	35.00	25.46	9.34
675 only #895 Taper Washer	9.39	9.39	9.70	9.90	8.24	8.97	10.89	12.27	12.12	5.25	12.31	15.01
50 only #896 Strain Strap	8.20	8.20	5.66	5.40	6.93	7.04	6.36	6.57	12.06	11.50	6.48	5.84
750 only #998 Square Plate	4.05	4.05	4.93	4.60	4.14	3.62	4.96	8.06	8.88	14.50	4.39	6.65
20 only Knuckle for Contact Wire per Dwg. #3-503782	27.25	27.25	15.45	21.04	24.15	49.50	18.20	17.85	89.25	38.00	15.65	13.04
40 only Bracket for Pulley per Dwg.#3-503658	32.70	32.70	19.55	28.79	19.40	24.45	15.08	33.30	121.15	56.50	34.65	37.83
56 only Angle Bar for Insulator Bracket per Dwg. #4-504154	15.52	15.52	14.14	14.59	14.43	12.05	14.93	23.08	22.25	23.50	9.98	30.87
12 only Surge Arrester Platform per Dwg. #3-504156	95.00	95.00	94.42	112.16	107.10	97.25	97.08	101.14	395.46	110.00	135.00	129.50
Transporation Cost to Prince George, BC	3,000.00	3,000.00	6,421.00	3,150.00	1,350.00	3,900.00	2,800.00	3,200.00	3,900.00	1,100.00	10,528.00	22,120.00
FIRM TOTAL COST DELIVERED	$ 164,128	$ 153,550	$156,474	$ 160,975	$ 167,016	$176,291	$ 182,134	$ 194,359	$ 233,601	$260,340	$ 235,122	$ 279,070
Delivery Lead Time for first shipment	4 weeks	4 weeks	4 weeks	4 weeks	4-6 weeks	4 weeks	3 weeks	3 weeks	6 weeks	T.B.A.	T.B.A.	6 weeks
Lead Time for Completion	12 weeks	18 weeks	8 weeks	14 weeks	8-10 weeks	10 weeks	9 wks pipe 6 wks bal	10 weeks	15-16 weeks	10 weeks	14 weeks ARO	10 weeks
Origin	BC	BC	BC	70% BC Bal. TBA	100% Cdn 20% BC	100% BC	100% Cdn 90% BC	100% BC	15% Cdn 85% foreign	100% BC	100% Cdn	T.B.A.

F.O.B. Prince George

SALES TAX Included

TERMS Net 30

50% Completion 50% Net 30

To be negotiated

MECHANICAL COMPONENTS AND ASSEMBLIES - SUMMARY OF COSTS

	High	Low	Average	Selected	Ratio Avg/Selected	Actual Contracted Value	% of Total
1. Special castings	1,831,293	950,633	1,270,793	950,633	1.36	1,049,149	47.85
2. Insulators	1,455,882	621,713	1,008,532	665,958	1.51	679,010	30.97
3. Tubing	110,520	110,520	110,520	110,520	1.00	110,520	5.04
4. Misc. Hardware	79,537	79,537	79,537	79,537	1.00	79,537	3.63
5. Nuts and bolts	243,305	138,576	190,940	138,028	1.38	143,028	6.52
6. Wire rope	43,800	8,134	22,285	11,739	1.89	11,739	0.54
7. Tunnel hardware	260,340	153,550	196,921	153,500	1.28	92,209	4.21
Guy wire *	27,133	27,133	27,133	27,133	1.00	27.133	1.24
TOTAL	4,051,810	2,089,996	2,906,661	2,137,048	1.36	2,192,325	100.00

* Purchased with Wire contract - see Appendix 7

APPENDIX 7

ELECTRICAL COMPONENTS AND ASSEMBLIES

WIRE
WIRE FITTINGS
WIRE CLAMPS
DROPPERS
SECTION INSULATORS
OVERLAP INSULATORS
SUMMARY

WIRES AND CABLES

The wire specification included in Volume II covers the manufacture, supply and delivery of the following wires and cables:

1. Contact wire - 107 mm^2 H.D. Copper Trolley Wire
2. Messenger wire - 70 mm^2 (19 strand) H.D. Copper
3. Feeder and earth wire - 4/0 ACSR Penguin
4. 50 kV Feeder wire - 322 mm^2 ASCR Goose
5. Guying strand - 3/8"" Grade 180 steel wire strand
6. a) Jumper wire 3/0 133 (G) strand
   b) Potential equilizers - No. 3 AWG 133 (H) strand
7. Ground wire to rails - AWG 1/0 19 (B)
8. Dropper wire - 5 mm diameter H.D. solid copper

Subsequent to the preparation of the specification and the tendering of the material, Item 7 was changed to an AWG 1/0 37 (C) flexible copper conductor (at no change in cost). This wire is used to connect the poles to the rails at pre-determined points along the track. The connection to the rail is via an exothermic connector and breakage of this connection due to rail movement is less likely with the more flexible wire. In addition to that change, two new items were added as follows for use at section insulator locations along the electrified line:

9. 250 MCM 19 strand H.D. copper (500 m at $7,120/km)
10. 250 MCM 259 G rope stranded copper (500 m at $9,112/km)

The contact wire and messenger wire were specified in variable reel lengths of 1,000 metres to 2,300 metres with the most common reel size being 1,500 metres to suit the requirements of variable section lengths which are site specific. The maximum section length in the auto-tensioned part of the line is 1,400 metres by design and in the fixed tension part of the line (i.e. through the long tunnels) the section length varies up to 2,300 metres.

The material was tendered in January 1983. Seven firms responded but only one quoted on all items. The price variations are summarized as follows and the details are tabulated on the following page.

ITEM	HIGH	LOW	AVERAGE	CONTRACTED
1	945,638	856,680	882,644	877,364
2	805,738	632,200	706,758	632,200
3	291,320	251,187	270,558	251,187
4	23,022	21,750	22,004	21,750
* 5	27,133	27,133	27,133	27,133
6 a	44,786	12,443	22,033	13,568
6 b	8,955	5,745	7,089	5,745
7	25,790	17,480	20,090	17,680
8	31,651	18,166	24,231	18,166
	2,204,033	1,842,784	1,982,540	1,864,793

The contract was awarded to Canada Wire and Cable Ltd. at a total value of $1,872,276.46 including the two new items discussed above (Items 9 and 10). Based on the purchase costs, unit prices are as follows:

ITEM	DESCRIPTION	COST/KM
1	Contact wire - 107 mm^2	$4,168.00
2	Messenger wire - 70 mm^2	2,180.00
3	Earth and feeder wire - 4/0 ACSR	1,055.85
4	50 kV feeder - 322 mm^2 ACSR	3,419.77
* 5	Guy strand - 3/8" Grade 180 steel	631.00
6 a	Jumper wire - 3/0 133 (G) strand	3,392.00
6 b	Potential equalizer - no. 3 AWG 133 (H)	1,149.00
7	Ground wire - AWG 1/0 37 (C)	1,168.00
8	Dropper wire - 5 mm diameter	586.00
9	Overlap jumper - 250 MCM 19 strand	7,120.00
10	Overlap jumper - 250 MCM 259 G	9,112.00

* Guy strand has been included as part of mechanical listing (see Appendix 6).

WIRES AND CABLES

Item Description	Quantity	Phelps Dodge	Can. Wire & Cable	Phillips Cables	Phillips Cables	Alcan	Anixter Turmac	Siemens	Anaconda Ericsson
1. 107 mm^2 H.D. Copper Trolley wire	210.5 km	864,834	877,364	945,638	873,405	NQ	NQ	856,680	877,944
2. 70 mm^2 H.D. Copper (19 strand)	290.0 km	671,980	632,200	762,120	705,860	662,650	NQ	NQ	805,738
3. 4/0 ACSR Penguin	237.9 km	NQ	251,187	270,095	270,095	270,095	291,320	NQ	NQ
4. 322 mm^2 ACSR Goose	6.36 km	NQ	21,750	21,750	21,750	21,750	23,022	NQ	NQ
5. 3/8 Grade 180 steel wire	43.0 km	NQ	27,133	NQ	NQ	NQ	NQ	NQ	NQ
6a. 3/0 133 (G)	4.0 km	12,443	13,568	20,440	18,929	NQ	NQ	NQ	NQ
6b. No. 3 AWG 133 (H)	5.0 km	NQ	5,745	8,955	8,295	NQ	NQ	NQ	44,786
7. AWG 1/0 37 (C)	10.0 km	18,085	17,680	25,790	23,880	NQ	NQ	NQ	5,363
8. 5 mm diameter H.D. Copper	31.0 km	19,185	18,166	31,651	29,326	NQ	NQ	NQ	22,827
Escalation		- 5%	Firm	Firm	*	*	*	*	Firm
*Subject to price escalation									
Deposit on reels		90,016	n.c.	77,978	77,978	46,942	n.c.	n.c.	-
Delivery		83/05/10	14 wks	83/05/10	83/05/01	83/05/10	83/05/10	83/05/10	83/05/10

WIRE FITTINGS

The requirement for wire fittings such as joints, splices, dead-end clamps, etc. was specified together with the wire in the same specification. The required items are all off-the-shelf stock items specified by manufactuers part or catalogue numbers. Several local distributors of the parts specified in the specification responded to the inquiry and their responses are tabulated on the following page. Based on these responses, orders were placed with:

ALCAN for the tubular compression joints at $874.00
SLACAN for 2500 saddle clamp and shackle at $25,025.00
NEDCO for all Burndy connectors and hardware at $13,794.49

The total value of all such wire fittings was $39,693.49.

INQUIRY NO P-28
RFQN NO 89905
DATE OF INQUIRY Jan 26,1983
CLOSING DATE NOON Feb 21,1983

⁑ NOT TO SPECIFICATION

F.O.B. PRINCE GEORGE B.C.

SUPPLY OF ELECTRICAL FITTINGS FOR THE TUMBLER RIDGE BRANCH LINE.

QUANTITY AND DESCRIPTION	QTY	BURNDY RICHMOND,B.C.	ALCAN CANADA VANCOUVER,B.C.	GESCAN VANCOUVER,B.C.	WESTINGHOUSE CANADA VANCOUVER,B.C.	E.B.HORSMAN VANCOUVER,B.C.	ERICO CANADA ST LAURENT QUEBEC	VAN HORNE NORTH VANCOUVER,B.C.	SLACAN HAMILTON ONTARIO	BALFOUR BEATTY KIRKBY ENGLAND	NEDCO NTH VANC
		PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE	PRICE
ITEM 1.Burndy YD S28RL Unisplice Full Tension Splice	200	1260.00	1260.00*	1178.00	1200.00	NQ	NQ	1222.00	1210.00*	2240.49*	(1167.98)
ITEM 2.Burndy CUW3QA-E Dead End Clamp	100	995.00	NQ	932.00	947.00	NQ	NQ	966.00	1495.00*	NQ	(922.33
ITEM 3.Alcan TJA-132 Tubular Compression Joint	25	NQ	874.00	NQ	NQ	NQ	NQ	NQ	NQ	668.06*	NQ
ITEM 4.Burndy YDS26 Hysplice Full Tension Splice	300	2550.00	NQ	2391.00	2427.00	NQ	NQ	2475.00	NQ	1765.58*	2363.77
ITEM 5.Burndy YPC28U28 Connector for Overhead Tap	800	564.80	NQ	529.12	536.00	NQ	NQ	547.84	NQ	1781.49*	(523.55
ITEM 6(a) Slacan 22361 Saddle Clamp	2200	NQ	NQ	13960.32*	NQ	NQ	NQ	14454.00*	13112.00	NQ	)
6(b) Slacan 6801 Shackle ½"	2200	NQ	NQ	13146.10	NQ	NQ	NQ	13596.00*	8910.00	NQ	)22799.00)
ITEM 7(a) Burndy YAL25T12 HYLUG	1600	2110.40	NQ	1883.52	1904.00	2320.00*	)	1950.24	NQ	1890.56*	1863.57
(b) Burndy YAL26T12 HYLUG	800	1108.00	NQ	1038.08	1048.00	1440.00*	)3288.00*)	1074.88	NQ	945.28*	1027.08
ITEM 8(a) Burndy HEB50 X 150 Bolt ½ x 1½	800	945.60	NQ	885.92	896.00	NQ	NQ	917.36	NQ	NQ	876.54
(b) Burndy HEN50 X 150 Hex Nut ½ x 1½	800	427.20	NQ	400.24	400.00	NQ	NQ	465.68	NQ	NQ	396.00
(c) Burndy FW 50 Flatwasher ½ x 1½	800	328.80	NQ	308.00	312.00	NQ	NQ	358.40	NQ	NQ	(304.79
(d) Burndy SW 50 Split Lockwasher ½ x 1½	800	306.80	NQ	287.44	288.00	NQ	NQ	334.40	NQ	NQ	284.39
TOTAL ITEMS 1-2-4-5-7-8 BURNDY.		10496.60		9833.32	9958.00			10311.80			9730.00
TOTAL ITEM 3 ALCAN.			874.00								
TOTAL ITEM 6 SLACAN.									22022.00		22799.00
ORIGIN.		CANADA	CANADA	CANADA	CANADA	CANADA	CDN / US	CANADA	CANADA	ENGLAND	CANADA
FREIGHT ALLOWED.		YES	NO	YES	YES	YES	YES	YES	YES	NO	YES
F.O.B.		PG	GRANDBY PQ	PG	PG	PG	PG	PG	PG	VANCOUVER	PG
SALES TAX		INCL	INCL	INCL	INCL	INCL	INCL	INCL	INCL	INCL	INCL
TERMS		NET 30	NET 30	NET 30	NET 30	NET 30	NET 30	NET 30	NET 30	NET 30	NET 30
		2 wks	4 wks	2-10 wks	8 wks	6-8 wks	2-3 days	2-6 wks	6 wks	11-18 wks	2-6 wks

WIRE CLAMPS

The overhead contact system design calls for the use of the following clamps:

1. Contact wire clamp as per Dwg. No. 3-503097 which is used for clamping the contact wire to the cantilevers (specifically the contact wire clamp sockets as per Dwg. Nos. 3-503112, 3-503113, 3-503114, or 3-503143).

2. Wire connector clamp as per Dwg. No. 3-503096 which is used for clamping two contact wires in parallel as required on Dwg. No. 3-503663, a special cantilever.

3. Hanger clamp - Brown Boveri, Type 1 for clamping the contact wire to the dropper as per Dwg. No. 3-503274.

4. Hanger clamp - Brown Boveri, Type V for clamping the messenger wire to the dropper as per Dwg. No. 3-503274.

5. Eye for droppers as per Dwg. No. 4-503278.

The five clamps were tendered seperately and the responses are summarized on the following page. The order were placed with Siemens for the quantities listed below at the unit prices offered by Siemens.

The total value of the order with Siemens amounted to $177,266.70.

Item 1	3,300 x $9.47	-	$31,251.00
Item 2	10 x $3,87	-	38.70
Item 3	22,600 x $3.20	-	72,546.00
Item 4	20,500 x $3.20	-	65,805.00
Item 5	41,000 x $ .186	-	7,626.00

FEBRUARY 21, 1983

TENDER P-8

CATENARY CLAMPS
TABULATION

ITEM	QUANTITY	DESCRIPTION	SJ RAILWAY	SIEMENS	GORDON RUSSELL MAIN	GORDON RUSSELL 1	GORDON RUSSELL 2	JOSLYN	OB CANADA	BALFOUR BEATTY
1	3200 ea.	Contact Wire Clamp per BCR Dwg. #3-503097	$ 8.26	$ 9.47	$ 23.23	$ 23.23	$ 23.23	$ 7.04	$ 19.95	NQ
2	10 ea.	Wire Connector Clamp per BCR Dwg. #3-503096	6.49	3.87	50.65	50.65	50.65	29.02	N/A	NQ
3	17,600 ea.	Hanger Clamp "Brown Boveri" Type 1 Cat #523-4.42 or equal, complete with #10 x 30 bolt, stainless steel A2-H65 and #10 nut, stainless steel A2-H6M	2.45	3.21	2.52	2.68	2.68	NQ	8.70	—
4	15,500 ea.	Hanger Clamp "Brown Boveri" Type V Cat #823-4.44 or equal, complete with #10 x 30 bolt, stainless steel grade A2-H65 and #10 nut, stainless steel grade A2-H6M	2.26	3.21	2.60	3.03	2.77	NQ	5.44	$74,923.00/LOT ITEMS 3, 4 & 5
5	31,000 ea.	Eye for Dropper per BCR Dwg. #4-503278	.30	.186	.34	.34	.34	.60	Not Required	
6		Transportation cost to Prince George, BC	$ 8,000.00	$ 5,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$600.00	Included	Extra
		Total Cost	$121,947.00	$147,359.70	$171,034.50	$180,515.50	$176,485.00		$301,280.00	
		Terms	Net 30	20% Down 80% Upon Shpt.	Net 30	Net 30	Net 30	Net 30	Net 30	Net 30
		FOB Point	Gothenburg, Sweden	Prince George, B.C.	Vancouver B.C.	Vancouver B.C.	Vancouver, B.C.	Pr. George, B.C.	Pr. George, B.C.	Vancouver, B.C.
		(Est. Theoretical Wt.)	10,000 Lbs.	12,430 Lbs.	10,406 Lbs.	10,406 Lbs.	10,406 Lbs.	4,700 Lbs.	18,000 Lbs.	TBA
		Delivery	14-20 Weeks	7-12 Weeks	50% - 6 Weeks 50% -10 Weeks	8 Weeks	7-8 Weeks ARO	12 Weeks ARO	50% - 8 Weeks 50% -12 Weeks	20 Weeks ARO
		Origin	Sweden	W. Germany	W. Germany & B.C.	W. Germany & B.C.	W. Germany & B.C.	Canada	U.S.A.	England

price includes all
Canadian taxes &
Transport to B.C.
include ½ shipping
[illegible]

DROPPERS (HANGERS)

The droppers or hangers to suspend the contact wire from the messenger wire are depicted in Dwg. No. 4-503274. The number of droppers required per span, their lengths, and the spacing of the droppers within each span is pre-calculated for varying span lengths in accordance with the weight-tensioning system (9.8 kN or 5.9 kN) and the system heights required at each end of the span. The pre-calculated values are tabulated in Dwg Nos. 3-504142, Sheet 1 through Sheet 21.

It will be noted that a maximum of eight droppers are used in any given span (maximum span length is nominally 70 metres by design). Site specific construction layout drawings are used to designate the particular dropper table to be used for any given span. Where the details of the span are not available until the span has benn constructed, (for example, where section insulators are used) the droppers can be cut and manufactured on site to suit. Otherwise, the droppers can be pre-cut and assembled as sets designated for a given span.

In some cases (in tunnels, for example), where the system height has been reduced to meet clearance requirements, the length of the dropper becomes quite short (less than 250 mm) and a different type of dropper as depicted on Dwg. No. 4-503279 is used. This type uses a suspension loop, thus eliminating the need for an upper clamp. Three lengths of loops are used as depicted on Dwg. Nos. 3-503280, 3-503281 and 3-503282. All utilize a protective channel as shown on Dwg. No. 3-503282 to protect the messenger wire.

The materials for the convential dropper (Dwg. No. 4-503274) have been discussed in the previous section. The assembly of the droppers, however were contracted with a firm in Prince George (Prince George Fabricating and Engineering Ltd.) at a unit price of $1.16 each (all materials provided by BCR). Only one other local firm (Northern Steel) indicated an interest in the assembly of the droppers (at a unit price of $2.50 each). The total value of the contract with Prince George Fabricating was $24,463.24.

The materials for the tunnel droppers were directed to EBCo at the following prices:

Drawing No.	Unit Cost	Quantity	Total
3-503280	$3.28	400	$ 1,312.00
3-503281	3.35	1,350	4,522.50
3-503282	3.58	900	3,222.00
3-503283	1.02	2,650	2,703.00
Total value of order			$11,759.50

SECTION INSULATORS

The specification for section insulators is included in Volume II. The characteristics of the section insulator are specified bearing in mind not only the overhead contact system characteristics in terms of electrical and mechanical requirements, but also the locomotive pantograph characteristics.

The insulators do not interrupt current collection by a passing pantograph when used singly as in the case of section insulators used to isolate specific sections of the electrified line from other parts or sections (for fault isolation, routine maintenance, etc.).

Two section insulators with a short strip of contact wire between them form a neutral section which will interrupt current collection when pantograph passes under it. Neutral sections are normally used to segregate segments of a given line such that each segment can be fed from a different source or a separate phase.

On the Tumbler Ridge Branch Line, a neutral section is used at the connection point of the series capacitor. (See Dwg. No. 2-504150).

The insulators were tendered in February 1983. Four firms responded and their offers are summarized below based on an order of 25 section insulators and 2 neutral sections delivered to Prince George.

	HIGH	LOW	AVERAGE	SELECTED
Lot Price	280,815	63,873	157,538	63,573

The Brown Boveri model offered by Gordon Russell was procurred (each twenty) at a price of $2,020.70 each. (Consists of contact wire insulator assembly at $1,487.14; messenger wire insulator assembly at $433.08; and a messenger-to contact wire suspension assembly at $100.48). The total value of the order was $40,674.00. The detailed tabulation of the responses from the four firms is on the following page.

TABULATION

INQUIRY NO. P-37

REQ'N. NO. 89919

DATE OF INQUIRY Feb. 8/83

CLOSING DATE, NOON --

F.O.B. Prince George, BC

QUANTITY AND DESCRIPTION	LAST PRICE	Gordon Russell Main PRICE	for accelerated delivery Alt. PRICE	O B Canada PRICE	Balfour Beatty PRICE	Kupler Corp. Main PRICE	for accelerated delivery Alt. PRICE	PRICE	PRICE	PRICE	PRICE
25 only Section Insulator Assy.											
2 only Neutral Section Assy.											
Total Lot Price Quoted	$	63,573	66,428	137,993	67,200£	247,950	279,415				
Exchange Amount	$	Inc.	Inc.	Inc.	56,986	Inc.	Inc.				
Duty @ 12.1% (TI 44510-1)	$	Inc.	Inc.	Inc.	15,027	Inc.	Inc.				
Federal SAles Tax @ 5%	$	Inc.	Inc.	Inc.	6,961	Inc.	Inc.				
Transportation	$	300	300	Inc.	300	1,400	1,400				
Total Cost Delivered	$	63,873	66,728	137,993	146,474	249,350	280,815				
Origin: Manufacturer		Brown Boveri		Ohio Brass	Balfour Beatty	Kupler Corp.					
Place of Manufacture		Munich West Germany		U.S.A.	Kirby England	Connecticut U.S.A.					
Delivery		22 wks ARO	18 wks ARO	16-24 wks ARO	27 wks ARO	1st unit 14 weeks	1st unit 12 weeks				
						Bal. 18 weeks	Bal. 14 weeks				
COUNTRY OF ORIGIN											
F.O.B.		Vancouver - Frt. added to P.George		Prince George	Vanc.Frt. added	Prince George					
SALES TAX											
TERMS		Net 30		Net 30	Net 30	Net 30					
DELIVERY											

OVERLAP INSULATORS

Overlap sections can be arranged in a special way to serve the same purpose as a section insulator. (See Dwg. Nos. 2-504157 and 2-504158). In lieu of a section insulator, two additional insulator rods or suspension insulators can be used in the specially arranged overlap. The insulator rods used with the section insulators would serve the purpose but a lightweight suspension insulator would also serve the purpose at a considerable cost saving.

A limited number of lightweight suspension insulators were tendered in May 1983 based on the RODURFLEX 43/21 (147)-110 manufactured by Rosenthal Technik AG. Three firms responded to the inquiry and shown on the following page. The order was placed with John McMillan for fifteen EPAC & ESTI-1210-5CC suspension insulators at a unit price of $90.00 and total order value of $1,350.00.

INQUIRY No. P-75

REQ'N. No. 90010

DATE OF INQUIRY May 6/83

CLOSING DATE, NOON May 31/83

F.O.B. PRINCE GEORGE B.C.

QUANTITY AND DESCRIPTION	PATTON AND COOKE SURREY B.C. LAST PRICE	O B CANADA DELTA B.C. PRICE	JOHN MC MILLAN VANCOUVER PRICE
15 Only SUSPENSION INSULATORS	308.00	132.49	90.00
30 Only CLEVIS CONNECTORS		13.32	
FREIGHT:	36.49	INCL	INCL
	344.49	145.81	90.00
COUNTRY OF ORIGIN	Germany	USA	Canada
F.O.B.	PG	PG	PG
SALES TAX	INCL	INCL	INCL
TERMS	30 Days	30 Days	30 Days
DELIVERY	13 Weeks	4-6 Weeks	6 Weeks

ELECTRICAL COMPONENTS AND ASSEMBLIES

Summary of Costs

	High	Low	Average	Selected	Ratio Avg/Selected	Actual Contracted Value	% of Total
1. Contact wire	945,638	856,680	882,644	874,364	1.01	877,364	40.63
2. Messenger wire	805,738	632,200	706,758	632,200	1.21	632,200	29.28
3. Ground & feeder wire	291,320	251,187	270,558	251,187	1.08	251,187	11.63
4. Misc. wire, etc. *	156,438	85,750	111,891	87,075	1.28	104,508	4.84
5. Wire fittings, clamps, etc.	294,206	294,206	294,206	294,206	1.00	294,206	13.62
TOTAL	2,493,340	2,120,023	2,266,057	2,142,032	1.06	2,159,465	100.00

* Includes Suspension Insulators; see Appendix 5 Summary.

APPENDIX 8

UNIT COSTS FOR MAJOR ASSEMBLIES

TOTAL MATERIAL COST ESTIMATES
MATERIAL COSTS PER KILOMETER
SUPPORT STRUCTURES
MECHANICAL COMPONENTS AND ASSEMBLIES
ELECTRICAL COMPONENTS AND ASSEMBLIES

UNIT COSTS FOR MAJOR ASSEMBLIES

TOTAL MATERIAL COST ESTIMATES

Material cost summaries for the three major categories of components and assemblies are tabulated on page 8-2. Each category has been discussed in some detail in Appendix 5, 6 and 7. A comparison of the cost for any given category versus the total cost for all three categories provides the following data:

Percentage of Total OCS Material Costs

Category/Estimate	High	Low	Average	Contracted
* Support Structures	28.31	31.63	30.46	31.91
Mechanical	44.38	31.94	39.08	34.30
Electrical	27.31	34.43	30.46	33.79
Total	100%	100%	100%	100%

* See further comments on page 8-3.

MATERIAL COSTS PER KILOMETRE

Material costs per kilometre of electrified line can be derived from the data shown on page 8-2. Since the material quantities actually ordered differed in many cases from the quantities tendered, it is necessary to adjust the high, low and average costs by the ratio of selected versus contracted costs. The adjusted cost variations are therefore as follows:

Category	High	Low	Average	Contracted
Support Structures	2,699,644	2,035,178	2,367,237	2,039,625
Mechanical	4,156,614	2,144,056	2,981,845	2,192,325
Electrical	2,513,632	2,137,277	2,284,500	2,159,465
Total	9,369,890	6,316,511	7,633,582	6,391,415

OVERHEAD CONTACT SYSTEM MATERIAL COST SUMMARY

	1	2	3	4	5	6	7	8
Material	High	Low	Average	Selected	Ratio Avg/Sel	Total Order Value	% of Subtotal	% of Total
Support Structures								
Poles	1,465,362	1,139,774	1,332,065	1,141,124	1.00	1,141,124	55.95	
Foundations	939,135	714,794	812,091	717,701	1.00	717,701	35.19	
Portals	159,597	93,500	121,759	93,500	1.93	180,800	8.86	
Subtotal	2,584,094	1,948,068	2,265,915	1,952,325	1.04	2,039,625	100.00	31.91
Mechanical								
Castings, etc.	1,831,293	950,633	1,270,793	950,633	1.10	1,049,149	47.85	
Insulators	1,455,882	621,713	1,008,532	665,958	1.02	679,010	30.97	
Nut and bolts	243,305	138,576	190,940	138,028	1.04	143,028	6.52	
Tubing	110,520	110,520	110,520	110,520	1.00	110,520	5.04	
Tunnel hardware	260,340	153,550	196,921	153,500	.60	92,209	4.21	
Misc. hardware	79,537	79,537	79,537	79,537	1.00	79,537	3.63	
Wire rope and guys	70,933	35,267	49,418	38,872	1.00	38,877	1.78	
Subtotal	4,051,810	2,089,996	2,906,661	2,137,048	1.03	2,192,325	100.00	34.30
Electrical								
Contact wire	945,638	856,680	882,644	877,364	1.00	877,364	40.63	
Messenger wire	805,738	632,200	706,758	632,200	1.00	632,200	29.28	
Ground & feeder wire	291,320	251,187	270,558	251,187	1.00	251,187	11.63	
Misc. wire, etc.	156,438	85,750	111,891	87,075	1.20	104,508	4.84	
Fittings, etc.	294,206	294,206	294,206	294,206	1.00	294,206	13.62	
Subtotal	2,493,340	2,120,023	2,266,057	2,142,032	1.01	2,159,465	100.00	33.79
GRAND TOTAL	9,129,244	6,158,087	7,438,633	6,231,405	1.03	6,391,415		100.00

Based on approximately 168 kilometres of electrified track on the BCR Tumbler Ridge Branch Line, the cost variation per track kilometre are as follows:

Category	High	Low	Average	Contracted
*Support Structures	17,761	13,389	15,574	13,418
Mechanical	24,742	12,762	17,749	13,050
Electrical	14,962	12,721	13,598	12,854
Total	57,465	38,872	46,921	39,322

*Support structures are based on 152 kilometres of track since the BCR Tumbler Ridge Branch Line includes approximately 16 kilometres of tunnels which require no poles, pole foundations or portals.

SUPPORT STRUCTURES

Cost estimates for poles, pole foundations and portals should be based on site-specific requirements whenever such data can be established. Given that the types and numbers of support structures can be estimated, the unit prices shown on page 8-4 can be applied to arrive at an estimate of the material costs for support structures. The appropriate figure (somewhere between the high and low) should be selected based on the state of the economy and the price of steel predicted for the time of procurement as compared to the state of the economy and the price of steel which existed in late 1982 and early 1983.

Given that the types and numbers of support structures cannot be estimated accurately, the overall estimate for support structures can be derived from the cost estimates for other categories of material for the OCS multiplied by the appropriate ratio of percentage cost per category as tabulated on page 8-1.

MATERIAL COST SUMMARY - SUPPORT STRUCTURES

Pole & Foundation	High	Low	Average	Contracted
C130 x 10, Type I	879	640	768	641
C130 x 13, Type I	955	714	843	715
C150 x 16, Type I	1,026	790	910	791
C250 x 30, Type I	1,558	1,201	1,348	1,201
C130 x 10, Type II	1,188	693	884	764
C130 x 13, Type II	1,264	767	959	838
C150 x 16, Type II	1,335	843	1,026	914
C250 x 30, Type II	1,950	1,251	1,496	1,359
C130 x 10, Type III	661	479	570	481
C130 x 13, Type III	737	553	645	555
C150 x 16, Type III	808	629	712	631
C250 x 30, Type III	1,340	1,041	1,149	1,042
Portals - 17 metre	3,275	1,910	2,620	2,090
- 18 metre	3,550	2,025	2,735	2,275
- 19 metre	3,840	2,135	2,860	2,460

MECHANICAL COMPONENTS AND ASSEMBLIES

This category or grouping received the widest variation in responses from the manufacturers. Unit cost figures for the major mechanical assemblies have been derived by interpolation, extrapolation and manipulation of the data summarized in Appendix 6. The major mechanical assemblies are reflected in the drawings included in Volume III of the main report.

Reference should also be made to the specifications contained in Volume II of the main report, in particular the specifications for special castings and fabricated components (Overhead Line Equipment Hardware and Tunnel Hardware Specifications).

The drawing numbers of the major mechanical assemblies are as follows:

ASSEMBLY NUMBER	DRAWING NUMBER	ASSEMBLY DESCRIPTION
1	3-503287	Single cantilever
2	3-503415	Single cantilever, inner curve
3	3-503579	Single cantilever, mid-point anchor
4	3032-5-4001	Tunnel catenary support assembly, CS1
5	3032-5-4002	Tunnel catenary support assembly, CS2
6	3032-5-4003	Tunnel catenary support assembly, CS3
7	3032-5-4004	Tunnel catenary support assembly, CS4
8	3032-5-4005	Tunnel catenary support assembly, CS5
9	3032-5-4006	Tunnel catenary support assembly, CS6
10	3032-5-4008	Tunnel catenary support assembly, CS7
11	3-503661	Parsnip River Bridge cantilever, Type A
12	3-503662	Parsnip River Bridge cantilever, Type B
13	3-503412	Single cantilever - portal center track
14	2-503573	Double cantilever - portal center track
15	2-503418	Double cantilever - electric section
16	2-503289	Double cantilever - switches
17	2-503288	Double cantilever - overlaps

ASSEMBLY NUMBER	DRAWING NUMBER	ASSEMBLY DESCRIPTION
18	2-503285	Weight tensioning - single track - 9.8 kN
19	2-503656	Weight tensioning - portal - 9.8 kN
20	2-503411	Mid-point anchors
21	3-503426	Feeder wire support
22	3-503420	Ground wire support

Cantilever Assemblies

Cantilever components vary depending on the type of cantilever required. Assembly numbers 1 through 17 represent the variety of cantilevers involved in the OCS of the BCR Tumbler Ridge Branch Line. In determining the unit costs for these assemblies, average lengths were assumed for top-ties, tubing and droppers. Unit costs were established from the cost data for components as contracted by interpolating the cost data on "sets" and "packages" as discussed in Appendix 6. The high, low and average costs were extrapolated from the overall costs after adjusting the overall costs for differences between the overall costs for the "selected" versus "contracted" costs. The unit costs for the cantilever assemblies are as follows:

Assembly Number	High	Low	Average	Contracted
1	822.75	284.90	448.69	298.77
2	878.40	313.79	487.31	327.66
3	872.37	310.66	483.13	324.53
4	740.69	402.46	534.40	402.46
5	979.29	543.14	714.87	543.14
6	1,118.12	625.00	819.89	625.00
7	758.99	413.25	548.24	413.25
8	805.84	441.14	584.02	441.14
9	821.74	450.25	595.71	450.25
10	1,206.21	676.94	886.52	676.94

Assembly Number	High	Low	Average	Contracted
11	800.09	273.14	432.97	287.01
12	807.22	276.84	437.91	290.65
13	1,349.41	558.20	814.03	572.07
14	2,759.41	1,148.04	1,670.36	1,175.78
15	1,745.88	621.91	967.04	649.65
16	1,636.51	565.14	891.15	592.88
17	1,629.70	561.60	886.42	589.34

Weight Tensioning Units

There are slight variations in material requirements depending on the type of pole on which the weight tensioning units are mounted. Assembly numbers 18 and 19 above (Dwg. Nos. 2-503285 and 2-503658) reflect those differences. The cost differences are minor as indicated below. The largest single cost of the weight tensioning unit is the cost of the weights themselves. For a 9.8 kN tensioning unit, 45 weights are required at a contracted cost of $30.00 each.

Assembly Number	High	Low	Average	Contracted
18	4,037.75	2,115.71	2,235.27	2,128.16
19	4,107.26	2,155.98	2,874.77	2,168.43

These costs assume the use of plate anchors and anchor rods as purchased under "miscellaneous hardware" for earth anchors. On the BCR Tumbler Ridge Branch Line, H-pile anchors were used where ever possible.

Mid-point Anchors

In addition to the need for a special cantilever at the mid-point anchor (see assembly number 3 above), additional insulators, guy wires and anchors are required. Most of these items are available off-the-shelf. Based on the use of plate anchors and anchor rods for earth anchors, the unit cost varies as follows:

Assembly Number	High	Low	Average	Contracted
20	474.31	370.28	416.97	370.28

Feeder Wire Support Hardware

The 4/0 ACSR feeder wire mounting material per pole consists of the insulator, its mounting stud and clamp, a specially fabricated mounting bracket, and the nuts and bolts to secure the pieces on the pole. A typical installation is depicted on Dwg. No. 3-503426. Cost variations were as follows:

Assembly Number	High	Low	Average	Contracted
21	187.41	140.16	157.82	140.16

Ground Wire Support Hardware

The ground wire support hardware consists of the saddle clamp (a standard off-the-shelf item), specially fabricated components as shown on Dwg. No. 3-503420 and the nuts and bolts to mount the pieces on the poles. Cost variations are as follows:

	High	Low	Average	Contracted
Assbly No. 22	38.60	23.38	29.47	23.38
With extension bracket	51.11	29.87	38.15	29.87

The ground wire is not connected to the rails at every pole, but at every second pole near the substation and varying up to every eighth pole farthest from the substation. See Dwg. No. 3-503779 for this connection. The cost of this connection is less than $14.00 per ground connection and its cost has not been included in the above figures.

ELECTRICAL COMPONENTS AND ASSEMBLIES

Wires and Cables

Wires and Cables are discussed in detail in Appendix 7 and a review of that data with the data presented earlier in this appendix indicates that this category of material for the OCS can be estimated with higher accuracy than any other category, i.e. the cost variations are small. The greatest inaccuracy in estimating material costs is in estimating the length of wire required per track kilometre. The unit costs of the various wires and cables per kilometre of wire was reported in Appendix 7.

The following is a tabulation of wire and cable cost variations per track kilometre (based on 168 km of track on the BCR Tumbler Ridge Branch Line) and on the per kilometre cable costs discussed in Appendix 7).

	High	Low	Average	Contracted
Contact wire	5,630	5,100	5,255	5,225
Messenger wire[1]	4,030	3,160	3,535	3,160
Earth or feeder wire 2	1,225	1,055	1,140	1,055
Misc. wire[3]	710	370	485	375

[1] Earth and feeder wire in tunnels are the same as the messenger wire.

[2] Earth and feeder wires are the same size.

[3] The miscellaneous wire includes the wire requirements for jumpers, potential equalizers, in-span droppers, and earth wire-to-rail connections.

In-span Electrical Components

In-span electrical components such as wire fittings, clamps, droppers, and insulators amount to approximately 4 to 5% of the total OCS material costs. The following costs per track kilometre are based on the contracted costs for this type of material as used on the BCR Tumbler Ridge Branch Line.

Wire fittings	$ 240.00
Wire clamps	870.00
Droppers	215.00
Insulators	250.00
Total	$1,575.00/kilometre

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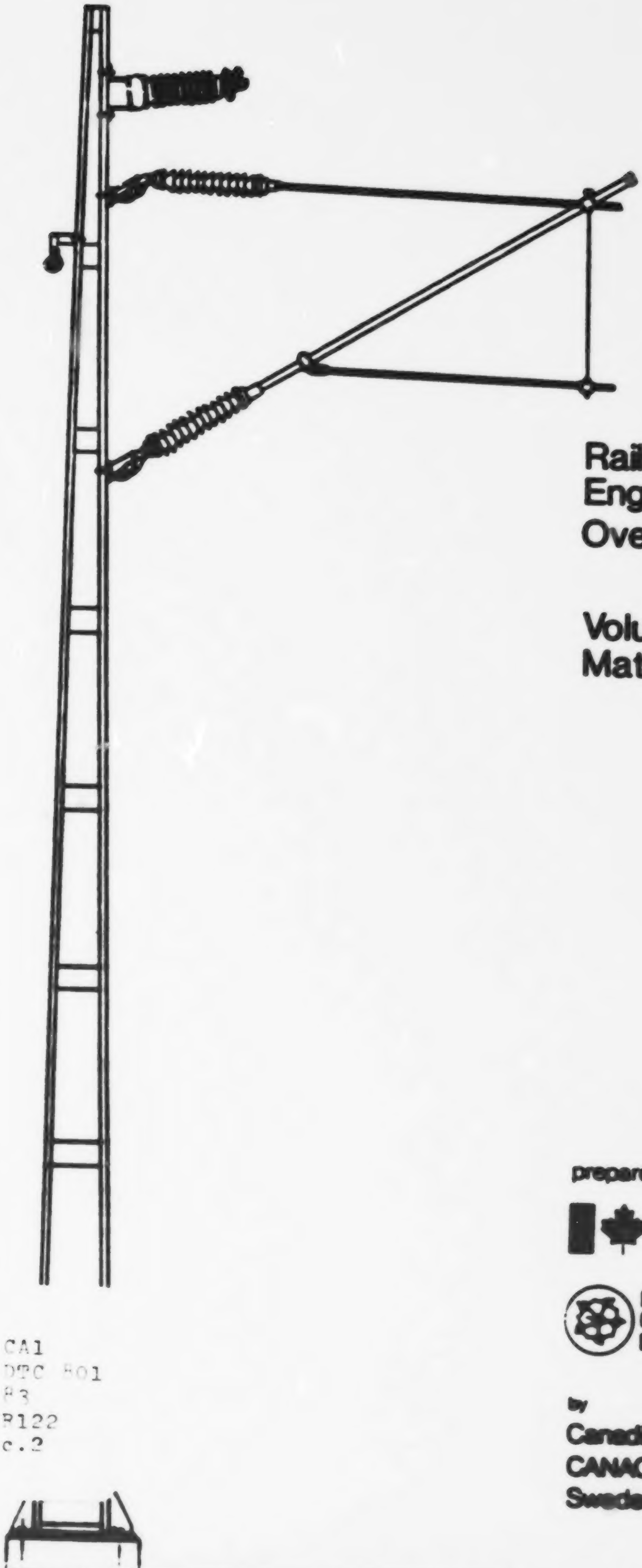

Railway Electrification Engineering and Sourcing Overhead Contact System

Volume II
Material Specifications

prepared for

Transportation Development Centre
Transport Canada

BRITISH
COLUMBIA
RAILWAY

by

Canadian Pacific Consulting Services Ltd.
CANAC Consultants Limited
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RAILWAY ELECTRIFICATION
ENGINEERING AND SOURCING
OVERHEAD CONTACT SYSTEM

VOLUME II: MATERIAL SPECIFICATIONS

Based on data obtained from
ELECTRIFICATION OF THE BRITISH COLUMIBA RAILWAY
TUMBLER RIDGE BRANCH LINE

Canadian Pacific Consulting Services Ltd.
Montreal, Canada
October 1983

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of Transport Canada, Transportation Development Centre.

PROJECT TEAM

The project team was comprised of personnel from the following organizations:

Canadian Pacific Consulting Services Ltd.
CANAC Consultants Limited
Swedish State Railways
International Engineering Company Ltd.

Foundation Design done by BCR Engineering Staff
Procurement done by BCR Material Management Staff

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REPORT DOCUMENTATION FORM

1. Transport Canada Report No. TP 4950 E	2. TDC Project No. 4760/61	3. Recipient's Catalogue No.

4. Title and Subtitle Railway Electrification - Engineering and Sourcing Overhead Contact System Volume II: Material Specifications	5. Report Date October 1983 6. Performing Organization Report No. C-82079
7. Author(s) M. Sugimoto L.C. Tait	8. Transport Canada File No. D1465-317-10
9. Performing Organization Name and Address Canadian Pacific Consulting Services Ltd. 740 Notre Dame Street West, Suite 760 Montreal, Quebec H3C 3X6	10. DSS File No. 11SD.T8200-2-2519 11. DSS or Transport Canada Contract No. 0SD82-00111
12. Sponsoring Agency Name and Address Transportation Development Centre 1000 Sherbrooke Street West, Suite 2421 Montreal, Quebec H3A 2R3	13. Type of Report and Period Covered Final, November 1983 14. Sponsoring Agency Code
15. Supplementary Notes Volume I: Design and Procurement Report Volume III: Component and Assembly Drawings	16. TDC Project Officer C.A. Versailles

17. Abstract

This report covers the engineering and sourcing information for an overhead contact system based on the data obtained from design and procurement for the electrification of the British Columbia Railway Tumbler Ridge Branch Line.

The report includes a summary of all design details including technical specifications for all material and design drawings for all components and parts requiring special manufacture or fabrication.

Copies of all material specifications have been compiled in a separate volume because of their bulk. Volume II of this report is dedicated to those specifications.

For ease of publication, all design drawings have been compiled in a separate document which is available as Volume III of this report.

The report also includes summaries of procurement data for all material required for the electrification of the Tumbler Ridge Branch Line, from which several conclusions are derived such that the cost of future electrification projects using the same or similar designs can be costed with reasonable accuracy.

18. Key Words Railway Electrification Overhead Contact System Design and Procurement	19. Distribution Statement A limited number of copies are available from the sponsoring agency.

20. Security Classification (of this report) Unclassified	21. Security Classification (of this page) Unclassified	22. No. of Pages 204	23. Price Nil

TDC/CDT 79 005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada TP 4950 E	2. N° de l'étude — CDT 4760/61	3. N° de catalogue du destinataire
4. Titre et sous-titre Railway Electrification - Engineering and Sourcing Overhead Contact System Volume II: Material Specifications		5. Date du rapport octobre 1983
		6. N° du rapport de l'organisme exécutant C-82079 -
7. Auteur(s) M. Sugimoto L.C. Tait		8. N° de dossier Transports Canada D1465-317-10
9. Nom et adresse de l'organisme exécutant Société d'études et de consultation du Canadien Pacifique (Ltée) 740 ouest, rue Notre-Dame, suite 760 Montréal, Québec H3C 3X6		10. N° de dossier — ASC 11SD.T8200-2-2519
		11. N° de contrat — ASC ou Transports Cana 0SD82-00111
12. Nom et adresse de l'organisme parrain Centre de développement des transports 1000 ouest, rue Sherbrooke, suite 2421 Montréal, Québec H3A 2R3		13. Genre de rapport et période visée finale, novembre 1983
		14. Code de l'organisme parrain
15. Remarques additionnelles Volume I: Design and Procurement Report Volume III: Component and Assembly Drawings		16. Agent de projet — CDT C.A. Versailles

17. Résumé

Ce rapport contient les donnéessur le design et l'information sur la provenance du matériel pour le système de contact aérien pour l'électrification de la ligne de Tumbler Ridge du B.C. Rail.

Le rapport comprend tous les détails de la conception ainsi que les spécifications techniques de tout le matériel et les dessins pour toutes les pièces ou composantes qui demandent une fabrication spéciale.

Les copies des données relatives aux spécifications des matériaux étant volumineuses, elles ont été incluses dans un volume séparé, notamment le volume II du présent rapport.

On trouvera également tous les dessins de conception au volume III de ce rapport.

On trouvera aussi dans le rapport et sous forme de sommaires, les données relatives à la fourniture des matériaux requis pour l'électrification de la ligne de Tumbler Ridge de B.C. Rail. Plusieurs conclusions sont tirées de ces sommaires qui permettront de faire des estimés relativement précis pourront être faits pour les projets d'électrification utilisant des systèmes du même genre.

18. Mots-clés Electrification des chemins de fer Système de contact aérien Conception et fourniture		19. Diffusion Un nombre limité de copies peuvent être obtenues de l'organisme parrain	
20. Classification de sécurité (de ce rapport) Aucune	21. Classification de sécurité (de cette page) Aucune	22. Nombre de pages 204	23. Prix -

CDT TDC 79-005

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the advice, assistance and data provided by the personnel of British Columbia Railway, in particular the Chief Engineer, Mr. V.W. Shtenko, and his engineering staff; and the Materials Manager, Mr. E.K.A. Focke and his Material Management staff.

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Specification for Overhead Line Equipment Hardware

SPECIFICATION FOR OVERHEAD LINE EQUIPMENT HARDWARE

FOR

BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES
MONTREAL, QUE.
82-12-22

SPECIFICATION FOR
OVERHEAD LINE EQUIPMENT HARDWARE

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge branch line for 50 kV 60 Hz operation. The project extends for some 130 route kilometres located as shown on sketch A attached.

2. SCOPE

2.1 This specification covers the design, manufacture, testing and supply of various items of overhead line equipment hardware.

2.2 To ensure compatibility of the various components when assembled, they are identified in sets and packages.

Suppliers are required to quote upon the provision of complete packages. Where components of sets and packages are not produced by the supplier, he is expected to obtain them and include them with the package.

3. STANDARDS

3.1 The following standards are applicable as specified on hardware drawings.

STANDARD	TITLE
CSA CAN3-G40.20-M81	General requirements for rolled or welded structural quality steel
CSA CAN3-G40.21-M81	Structural quality steels
CSA W59-1977	Welded steel construction (Metal Arc Welding)
CSA G164-1965	Hot dip galvanizing of irregularly shaped articles
ASTM A220-76	Pearlitic malleable iron castings
ASTM A325-74	High strength bolts for structural steel joints including suitable nuts and plain hardened washers

4. DRAWINGS & TOTAL QUANTITIES OF COMPONENTS

The following quantities are the summations of the components included in the packages of Section 5 which includes an additional quantity of approximately five percent for spares and wastage.

DRAWING NO.	NAME	QUANTITY
4-503045	Support loop	2,800
3-503046	Steering ring	300
3-503048	Tube link 27 mm	2,650
4-503049	Clevis joint	500
3-503050	Tube socket 55 mm	3,015
3-503051	Tube fitting	2,800
4-503053	Top-tie	2,600
4-503054	Suspension rod	300
3-503055A	Tensioning link	300
3-503056	Wedge clamp	2,600
4-503057	Tensioning fork	600
4-503061	Pin 19 x 100	500
4-503062	Pin 19 x 54	5,700

DRAWING NO.	NAME	QUANTITY
3-503063	Pulley axle	600
3-503064	Square pole L-3400	75
4-503065	Cross link	300
3-503066	Tensioning link	300
4-503067	Pulley (tensioning)	600
4-503069	Link	300
4-503072	Stud (messenger support)	2,800
4-503073	Holder on	150
3-503076	Clamp messenger channel	125
4-503077	Tensioning link	300
2-503078	Tensioning balance	300
3-503081	Wedge clamp	650
4-503089	Pin	2,300
4-503090	Retainer pin	5,615
3-503096	Wire connector	10
3-503097	Contact wire clamp	3,200
4-503109	Hookscrew 04-14-002-6	11,000
	04-14-001-8	11,000
	04-14-003-4	2,000
4-503110	Hookscrew (04-14-012-5)	2,500
3-503111	Tensioning weight	12,400
3-503112	Socket for contact wire	2,700
3-503113	Socket for contact wire	15
3-503114	Socket for contact wire	160
4-503115	Bolt	11,740
4-503116	Pin 13 x 44	3,015
3-503121	Bracket insert 42 mm	425
3-503123	Messenger channel	2,800
3-503124	Clamp for messenger	2,700
2-503125	Hinge for cantilever bracket	5,200
5-503127	"U" bolt	300
2-503128	Cantilever pivot bracket	4,000
3-503130	Bracket	2,300
2-503131	Mounting beam	600

DRAWING NO.	NAME	QUANTITY
3-503132	Hinge holder	170
3-503133	Mounting beam	850
3-503134	Lower bracket	300
3-503135	Upper bracket	300
4-503136	Head of attachment	1,200
4-503138	Tensioning holder	600
3-503139	Tensioning holder	60
3-503141	Steady arm hook	325
3-503142	Steady arm tube	325
3-503143	Steady arm socket	325
3-503144	Catenary hanger	40
4-503147	Insulator cap	4,600
4-503574	Bracket for feeder wires (Portal)	55
4-503416	Mounting bar sq. pole	425
4-503414	Protective cap for 55 mm tube	2,800
3-503419	Bracket feeder wire	1,500
3-503421	Tube link 42 mm	340
3-503422	Clevis link	2,600
3-503424	Tube connector 42 mm	40
4-503571	Distance bar	130
4-503575	Angle bar (sq. pole mounting)	20
3-503876	Bracket for pulley	5
4-503584	Brass plate	600
3-503657	Mounting beam tension	35
3-503776	Clevis link	300
3-503570	Hinge bracket	300
4-503581	Attachment for steady arm	40
4-503674	Attachment for registration support	16
4-503675	Registration support	16
3-503670	Distance bar	10
4-503671	Plate 65 x 35 x 6	75
4-503413	Tensioning holder	250
3-503429	Bracket for mounting earth wire suspension	500
3-503780	Grounding bracket	700
4-503278	Eye for dropper	31,000

DRAWING NO.	NAME	QUANTITY
4-503283	Grommet	2,200
3-503577	Pulley fork	45
3-503578	Pulley	45
3-503580	Head of attachments (½" screw)	1,400

5. DETAILED DESCRIPTION, TECHNICAL REQUIREMENTS AND QUANTITES

The following tabulation is a detailed description of sets of hardware grouped in packages and the required quantities. Technical requirements are detailed on the drawing referenced to each component.

PACKAGE No. 1

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
1	2,670	1,2,5,6,8, 9,10,11	3-503048	Tube link	2,670
			3-503050	Tube socket	2,670
			4-503090	Retainer pin	2,670
			4-503115	Hex bolt	5,340
			4-503116	Pin	2,670
2	2,700	1,2,5,6,8 9,10,11	3-503112	Socket	2,700
			4-503115	Hex bolt 1/2"	2,700
3	2,800	1,2,3,4,5 6,7,8,9, 10,11	4-503045	Support loop	2,800
			3-503051	Tube fitting	2,800
			4-503072	Stud	2,800
			3-503076	Clamp for messenger	125
			4-503115	Hex bolt	2,800
			3-503123	Messgr. wire channel	2,800
			3-503124	Clamp for messenger	2,700
				Brass washer 20x36x3	2,800
				Brass pin 6.3x36	2,800

PACKAGE No. 1 (cont'd.)

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
7	340	3,4,5	4-503115	Hex bolt (2)	680
			3-503050	Tube socket	340
			3-503421	Tube link	340
			3-503116	Pin 13 x 44	340
			4-503090	Retained pin	340
8	160	3,4	3-503114	Socket contact wire	160
			4-503115	Bolt	160
9	40	3	3-503424	Tube connector	40
			3-503144	Catenary hanger	40
			4-503115	Bolt	40
11	10	2	3-503113	Socket (contact wire)	15
			4-503115	Bolt	15
16		6	4-503781	Cantilever dropper	
				L-380 mm Part no. 1	25
				L-654 mm Part no. 2	15
				L-995 mm Part no. 3	15
				L-1045 mm part no. 4	2,100
				L-1195 mm Part no. 5	20
				L-1245 mm Part no. 6	15
				L-1295 mm Part no. 7	255
				L-1445 mm Part no. 8	140
				L-1795 mm Part no. 9	25
17	410	4,5	3-503121	Filling (55 mm to 42 mm)	425

PACKAGE No. 1 (cont'd.)

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
18	5	7	3-503050	Tube socket	5
			4-503090	Retainer pin	5
			4-503116	Pin 13 x 44	5
			4-503115	Bolt	5

PACKAGE No. 2

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
4	4,000	1,4 & 5	4-503062	Pin	4,000
			4-503090	Retainer pin	4,000
			2-503125	Hinge	4,000
			2-503128	Pivot bracket	4,000
			4-503147	Insulator cap	4,000
5	2,300	1,2,3,4,	3-503130	Bracket	2,300
		5 & 6	4-503089	Pin	2,300
			3-503422	Clevis link	2,300
5A	500	1	3-503429	Bracket	500
6	1,500	1,2 & 6	3-503419	Feeder wire bracket	1,500
	55	-	4-503574	Feeder wire bracket (portal)	55
10	600	2,3,6,9	2-503131	Mounting beam	600
			2-503125	Hinge bracket (2)	1,200
			4-503062	Pin 19 x 54 (2)	1,200
			4-503090	Retainer pin	600
			4-503147	Insulator cap	600

PACKAGE No. 2 (cont'd.)

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
10			4-503584	Brass plate	600
12	170	7,8,10	4-503049	Clevis joint	170
		11	3-503132	Hinge holder	170
			4-503061	Pin 19 x 100	170
			4-503062	Pin 19 x 54	170
			4-503090	Retainer pin (2)	170
12	330	-	4-503049	Clevis joint	330
			4-503061	Pin 19 x 100	330
			4-503062	Pin 19 x 54	330
			4-503090	Retainer pin	330
13	275	10	4-503416	Angle bar	275
14	75	10 & 11	3-503064	Square pole L-3400	75
15	20	11	4-503575	Angle bar	20

PACKAGE No. 3 - CLAMPS

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
2	2,730	1,2,5,6, 8-11	3-503097	Contact wire	2,730
8	140	3,4	3-503097	Contact wire	140
11	20	2	3-503097	Contact wire	20
19	5	7	3-503097	Contact wire	5
		(In tunnel)	3-503097	Contact wire	305
			3-503096	Wire connector	10

PACKAGE #4 - HOOKSCREW

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
4	8,000	1,4,5	4-503109	Hook screw (04-14-002-6)	8,000
5	5,000	1,2,3,4 5 & 6	4-503109	Hook screw (04-14-001-8)	5,000
6	6,000	1,2,6	"	(04-14-001-8)	6,000
10	3,000	2,3,6,9	"	(04-14-002-6)	3,000
12	550	7,8,10,11	"	Screw 3/4 UNCX140 with nut	550
13	1,900	10	"	Hook screw (0414003-4)	1,900
15	100	11	"	Hook screw (0414003-4)	100
	100			Screw 3/4 UNCX140	100
	2,250			Screw 3/4 x 178	2,250
	250		4-503110	Hook screw (04-14-012-5)	250
	750		4-503109	Hook screw (04-14-003-6)	750
	200			Screw 3/4 UNCX305	200
	900			Screw 3/4 UNCX45	900
	1,000			Screw 1/2 UNCX40	1,000

PACKAGE No. 5 - WEIGHT TENSIONING

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
20	600	12 & 13	4-503067	Pulley	600
			4-503057	Pulley axle	600
			3-503063	Tensioning fork	600
21	300	12 & 13	3-503056	Wedge clamp (2)	600
			2-503078A	Tensioning balance	300
			3-503055A	Link	300
			3-503081A	Wedge clamp (2)	600
22	300	12 & 13	3-503056	Wedge clamp (2)	600
			4-503069A	Link	300
23	300	12 & 13	3-503066	Tensioning link	300
			4-503077	Tensioning link	300
			3-503056	Wedge clamp	300
24	300	12 & 13	4-503054	Suspended rod	300
			3-503056	Wedge clamp	300
25	300	12 & 13	3-503046	Steering ring	300
26 & 28	300	12 & 13	3-503135	Upper bracket steering tube	300
			5-503127	"U" bolt	300
			4-503136	Head of attachment (2)	600
27 & 29	300	12 & 13	3-503134	Lower bracket steering	300
			4-503136	Head of attachment (2)	600
30	280	13	3-503065	Double clevis	280
			3-503776	Clevis link	280
			3-503133	Mounting beam (2)	560
37		12 & 13	3-503111	Tensioning weight	12,400

PACKAGE No. 5 (cont'd.)

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
31	290	12	3-503133	Mounting beam (guying)	290
32	600	12	4-503138	Mounting iron	600
			3-503056	Terminating clamp	600
33	35	13	3-503657	Mounting beam	35
34	35	13	3-503139	Mounting iron	35
			3-503056	Terminating clamp	35
35	20	12	3-503065	Double clevis	20
			3-503776	Clevis link	20
			3-503657	Mounting beam	20

PACKAGE No. 6

This package comprises the components which attach the droppers to the messenger and contact wires. The messenger wire is 70 mm^2 Hard Drawn Stranded (19 wire) copper per ASTMB8. Its diameter is 0.427 inches (10.85 mm).

The contact wire is 4/0 Grooved Copper trolley wire per ASTM B47-64. The bidders attention is particularly directed to the groove dimensions of figure 1 of this standard, of which a copy is attached.

COMPONENT	DESCRIPTION	QUANTITY
Hanger clamp	Brown Boveri Type I Catalogue no. 523-4.42 (or equivalent)	17,600
Hanger clamp	Brown Boveri Type V Catalogue no. 523-4.44	15,500

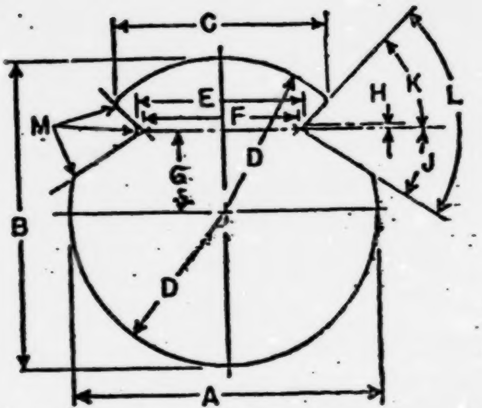
Each Hanger Clamp shall come equipped with a stainless steel A2-M65 10 x 30 bolt and A2-M6M 10 nut.

COMPONENT DRAWING NO.	DESCRIPTION	QUANTITY
4-503278	Eye for dropper	31,000
4-503283	Grommet	2,200

PACKAGE No. 7

This package consists of various lengths of a forged steel top tie which forms the top member of most cantilevers.

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
36		1,2,3,6,7	4-50353	Top Tie	
		8,9,10 & 11		L-1600 mm	5
				L-1800 mm	35
				L-2000 mm	30
				L-2200 mm	495
				L-2400 mm	380
				L-2600 mm	400



Note—Dimension *H* is defined by two center lines, of which the upper is the center line of the radius of the groove and the lower is the center line of the groove.

Nominal size, cmils	133 100	167 800	211 600	300 000	350 000
Area, in.^{2} (Note 4)	0.1083	0.1314	0.1665	0.2355	0.2758
Area, cmils (Note 4)	137 900	167 300	212 000	299 800	351 200
Weight, lb/mile (Note 4)	2205	2674	3389	4792	5612
Dimensions for Inspection, in.					
A	0.388 + 0.006 − 0.012	0.429 + 0.006 − 0.012	0.452 + 0.006 − 0.012	0.574 + 0.010 − 0.020	0.620 + 0.010 − 0.020
B	0.392 ± 0.007	0.430 ± 0.008	0.482 ± 0.009	0.574 ± 0.011	0.620 ± 0.012
C	0.318 ± 0.007	0.340 ± 0.007	0.376 ± 0.007	0.376 ± 0.007	0.376 ± 0.007
Dimensions for Reference, in.					
D—radius	0.196	0.215	0.241	0.267	0.310
E	0.217 + 0.005 − 0.010	0.237 + 0.005 − 0.010	0.267 ± 0.010	0.267 ± 0.010	0.267 ± 0.010
F	0.200	0.220	0.250	0.250	0.250
G	0.031	0.047	0.063	0.127	0.156
H	0.005	0.005	0.005	0.005	0.005
J	27 ± 2 deg	27 ± 2 deg	27 ± 2 deg	27 ± 2 deg	27 ± 2 deg
K	51 ± 2 deg	51 ± 2 deg	51 ± 2 deg	51 ± 2 deg	51 ± 2 deg
L	78 deg	78 deg	78 deg	78 deg	78 deg
M—radius	0.015 + 0.010 − 0.005	0.015 + 0.010 − 0.005	0.015 + 0.010 − 0.005	0.015 + 0.010 − 0.005	0.015 + 0.010 − 0.005

FIG. 1 Standard Sections Grooved Trolley Wire.

PACKAGE No. 7 (Cont'd.)

SET NO.	NO. OF SETS	SKETCH NO.	COMPONENT DWG. NO.	DESCRIPTION	TOTAL QUANTITY
				L-2800 mm	560
				L-3000 mm	40
				L-3200 mm	480
				L-3400 mm	85
				L-4000 mm	15

PACKAGE No. 8 - STEADY ARM ASSEMBLY

The package comprises an assembly of components for the steady arm in tunnels and on the Parsnip River bridge as per drawing no. 3-503140.

COMPONENT DRAWING NO.	DESCRIPTION	TOTAL QUANTITY
3-503141	Steady arm hook	325
3-503142	Steady arm tube	325
3-503143	Steady arm socket	325

Note: These components are required assembled per drawing 3-503140.

PACKAGE No. 9

This package comprises miscellaneous components required for the cantilever tunnels and in the portal structure (centre track).

COMPONENT DRAWING NO.	DESCRIPTION	TOTAL QUANTITY
3-503570	Hinge bracket	300
4-503416	Holder for pole	150
4-503581	Attachment for steady arm	40

PACKAGE No. 9 (Cont'd.)

4-503674	Attachment for registration support	16
4-503675	Registration support	16
4-503671	Plate 65 x 35 x 6	75
4-503073	Back plate	150
4-503571	Distance bar L-1000	130
4-503670	Distance bar L-1700	10
3-503576	Bracket for pulley fork	5
3-503577	Pulley fork	45
3-503578	Pulley	45
3-503414	Protective cap for 55 m	2,800
4-503061	Tube pin 19 x 100	330

PACKAGE No. 10

This package comprises components required for the grounding of the earth wire at the pole.

COMPONENT DRAWING NO.	DESCRIPTION	TOTAL QUANTITY
3-503780	Grounding bracket	700
3-503580	Head of attachment (2) (1/2" screw)	1,400

PACKAGE No. 11

This package comprises miscellaneous components for mid-point anchoring.

PACKAGE No. 11 (Cont'd.)

COMPONENT DRAWING NO.	DESCRIPTION	TOTAL QUANTITY
3-503056	Wedge clamp	1,700
3-503137	Tensioning holder	60
3-503422	Clevis link	300

( ) Number in brackets where shown indicates quantity per set.

6. ACCEPTANCE TESTS

The supplier shall demonstrate compliance with the technical specifications and to the relevant CSA and ASTM and other standards to the engineer. In addition to the above, the supplier shall demonstrate to the engineer that the sets and components comply with the technical specification before proceeding with full scale production.

7. SHIPPING & HANDLING

7.1 Sets shall be crated and delivered in quantities to be specified in the purchase order.

7.2 Packages shall be so marked as to clearly identify its contents by drawing number and quantity of components.

7.3 Delivery to British Columbia Railway site in the project area to be specified in the purchase order shall begin as soon after February 28, 1983 as possible with delivery of 50% of the hardware by April 10, 1983 and fully delivered by May 10, 1983.

8. OWNERSHIP OF MOLDS

8.1 One completion of the delivery of the castings the molds shall be turned over to B.C. Railway who retain proprietary right to their use.

9. INFORMATION TO BE SUBMITTED WITH THE TENDER

The bidders shall submit the following information when tendering.

1. Principal product line;

2. Annual volume of sales;

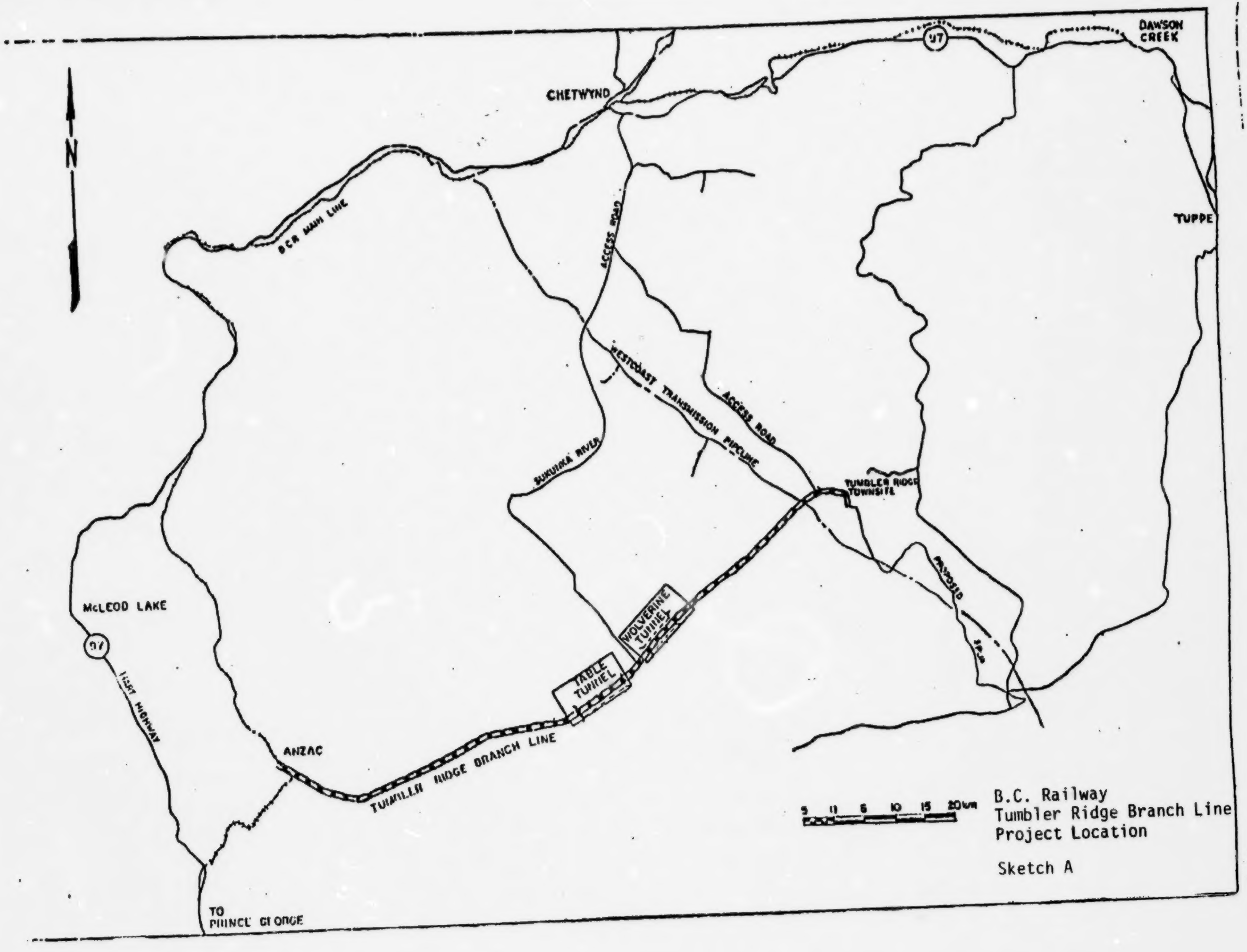
3. Annual volume of sales in product line described in this specification;

4. No. of people employed:
    a) professionals;
    b) skilled labour;
    c) non skilled labour.

5. Attach description of manufacturing facilities;

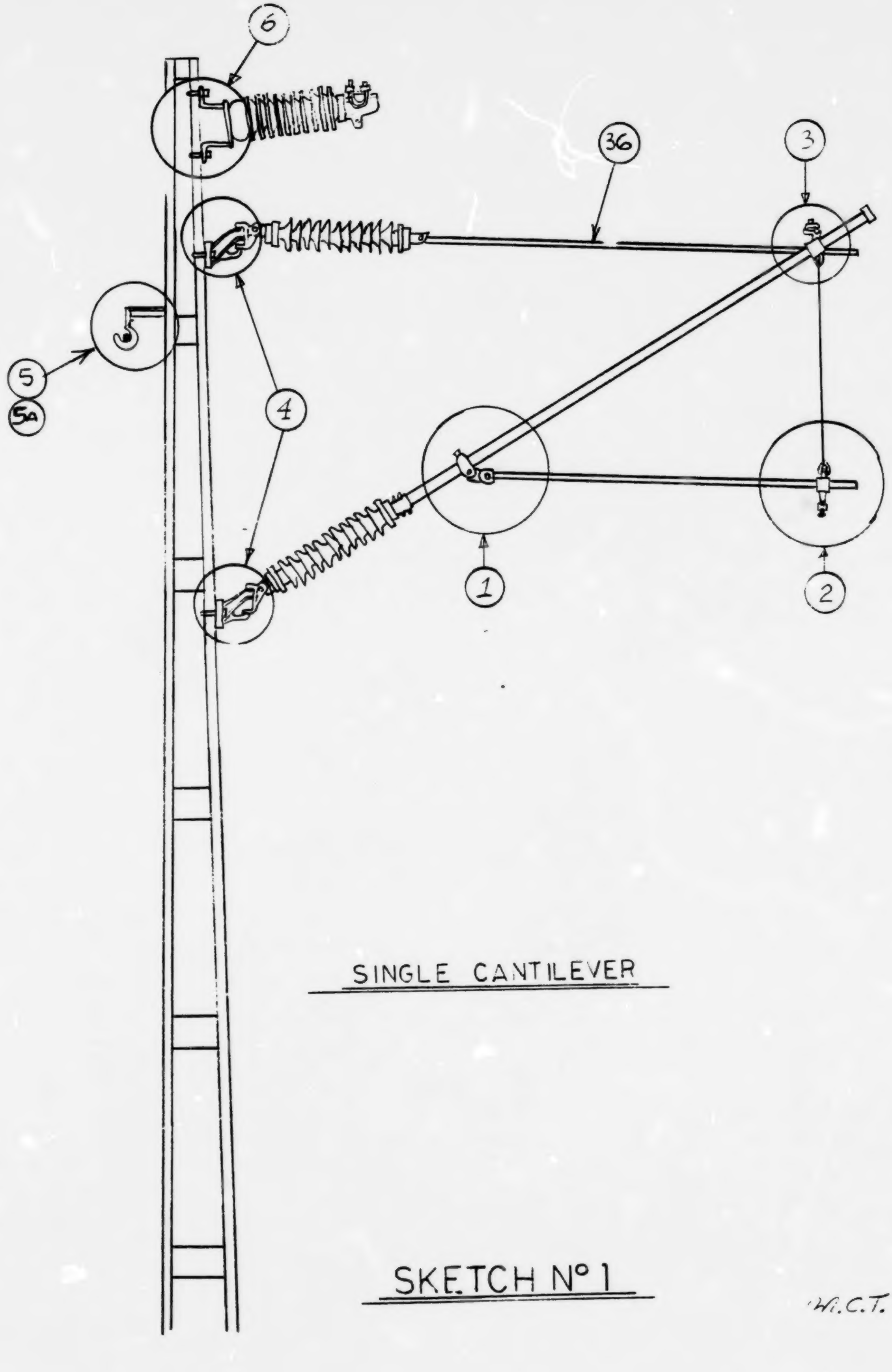
6. Any other information on company relevant to this tender;

7. State if your tender complies in every respect with the specification - yes/no;


N
DAWSON CREEK
97
CHETWYND
TUPPE
BCR MAIN LINE
ACCESS ROAD
WESTCOAST TRANSMISSION PIPELINE
ACCESS ROAD
SUKUNKA RIVER
TUMBLER RIDGE TOWNSITE
PROPOSED SPUR
WOLVERINE TUNNEL
TABLE TUNNEL
TUMBLER RIDGE BRANCH LINE
ANZAC
McLEOD LAKE
97
HART HIGHWAY
TO PRINCE GEORGE
5 0 5 10 15 20km

B.C. Railway
Tumbler Ridge Branch Line
Project Location

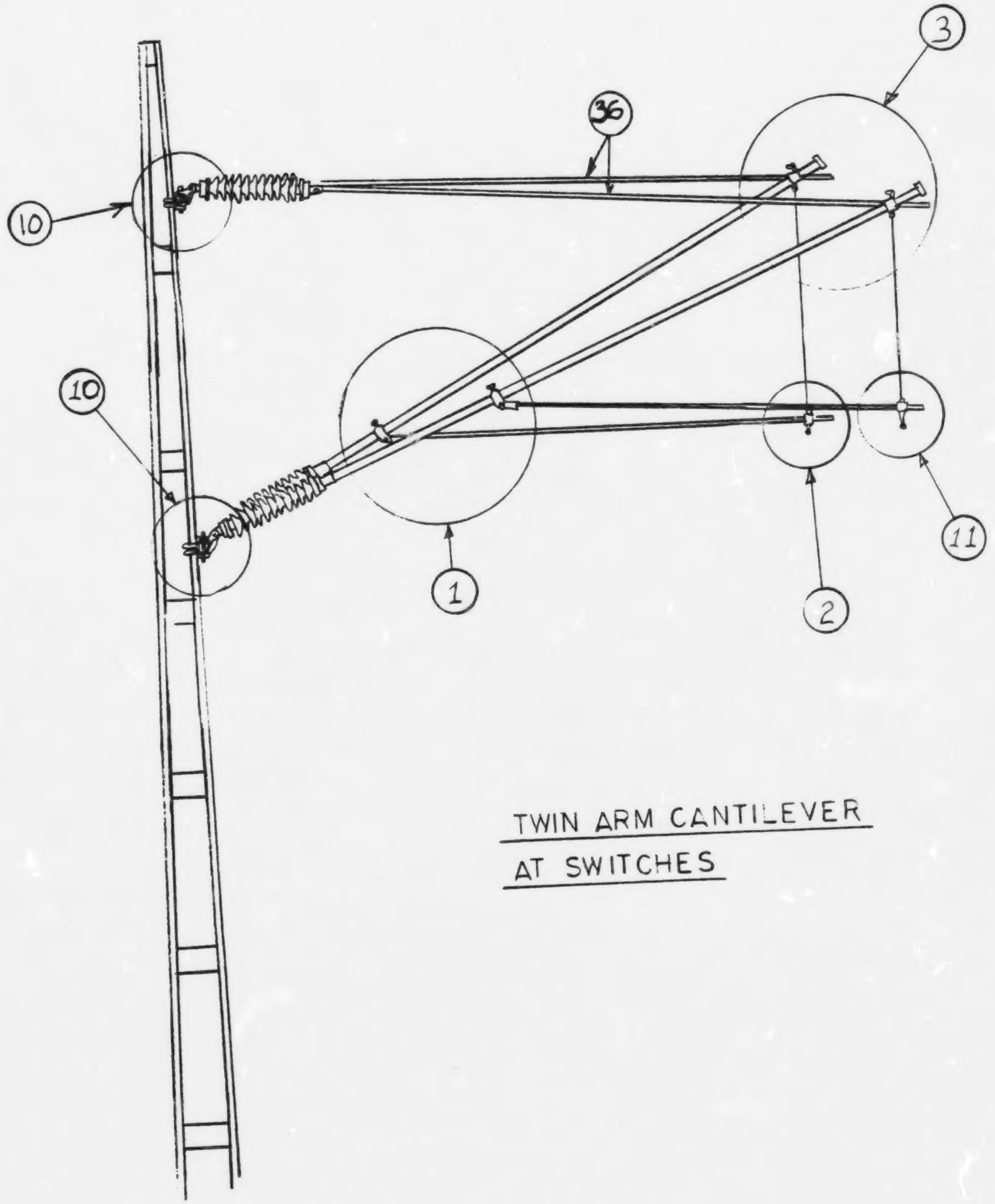
Sketch A


6
36
3
5
5A
4
1
2

SINGLE CANTILEVER

SKETCH N° 1

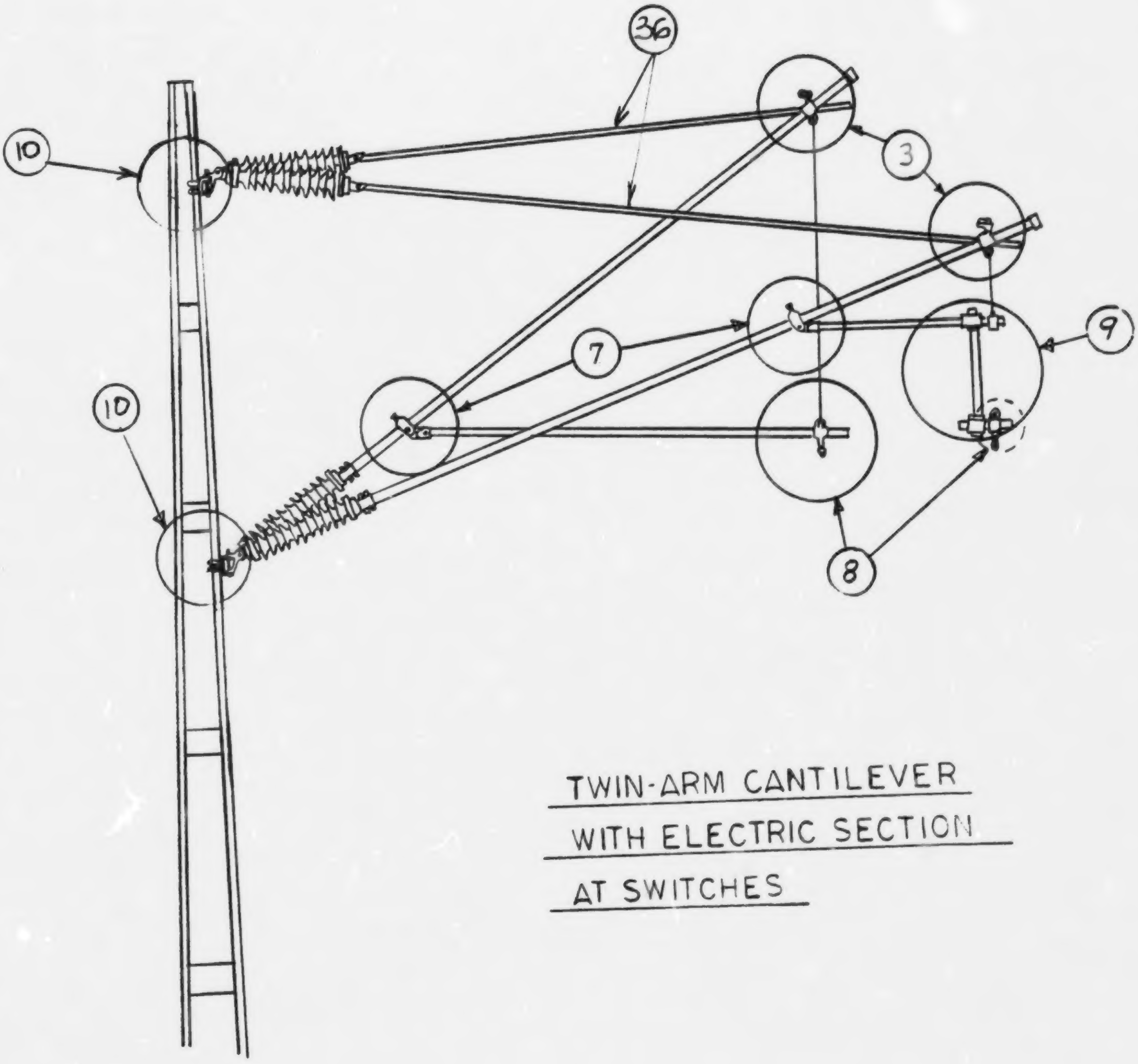
W.C.T. 821115


36
3
10
10
1
2
11

TWIN ARM CANTILEVER
AT SWITCHES

SKETCH Nº 2

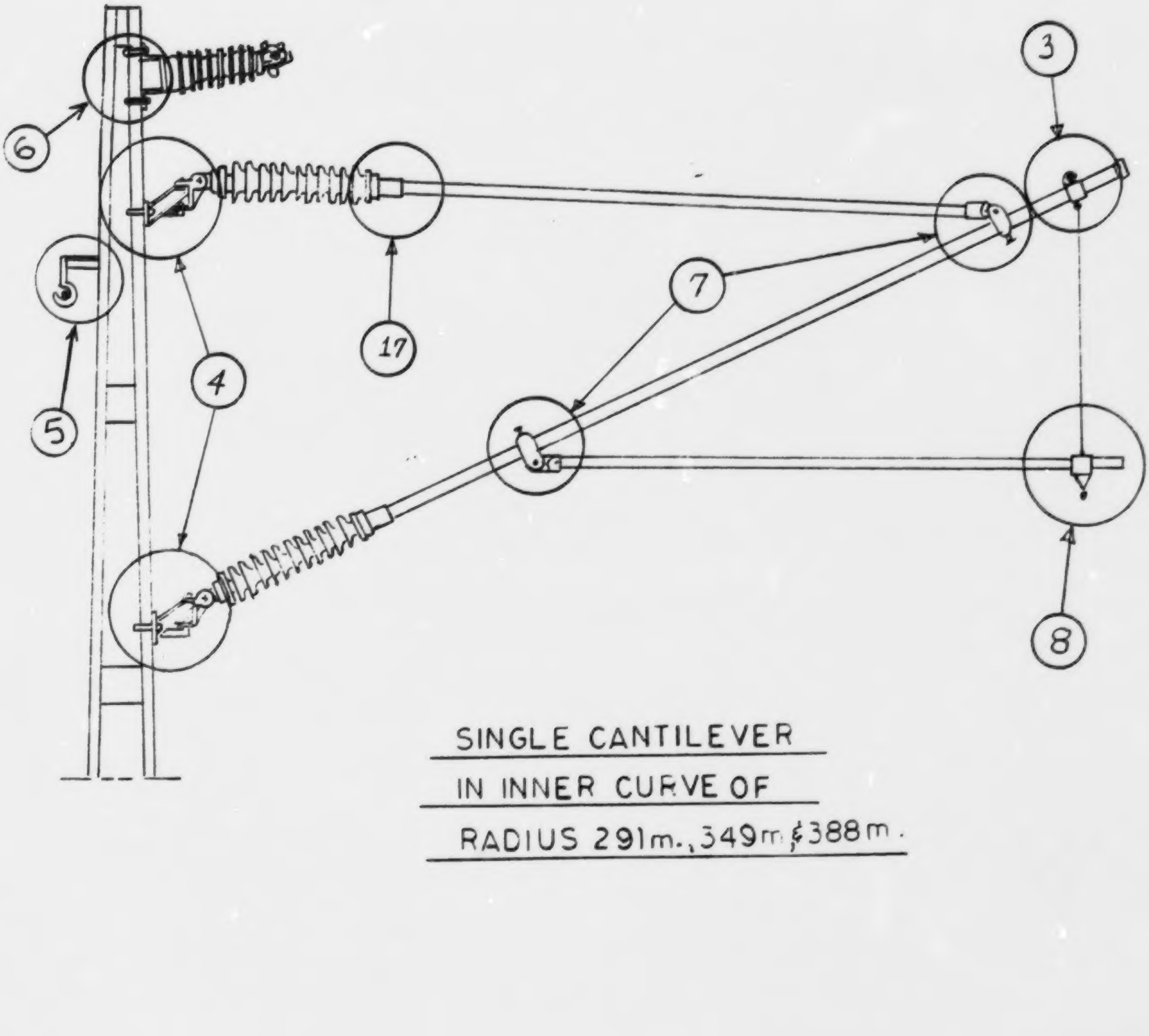
W I C T. 321125


36
10
3
10
7
9
8

TWIN-ARM CANTILEVER
WITH ELECTRIC SECTION
AT SWITCHES

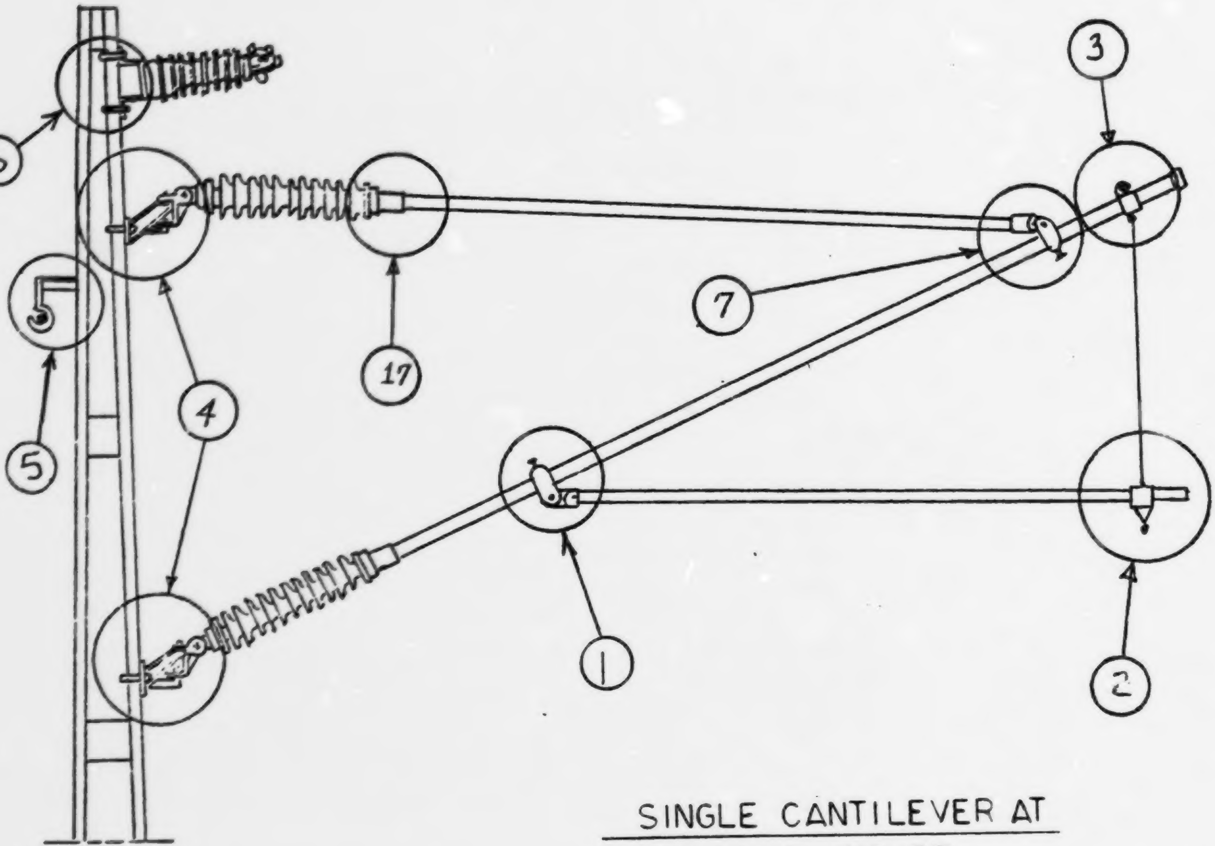
SKETCH N° 3

M.C.T. 82 11 23



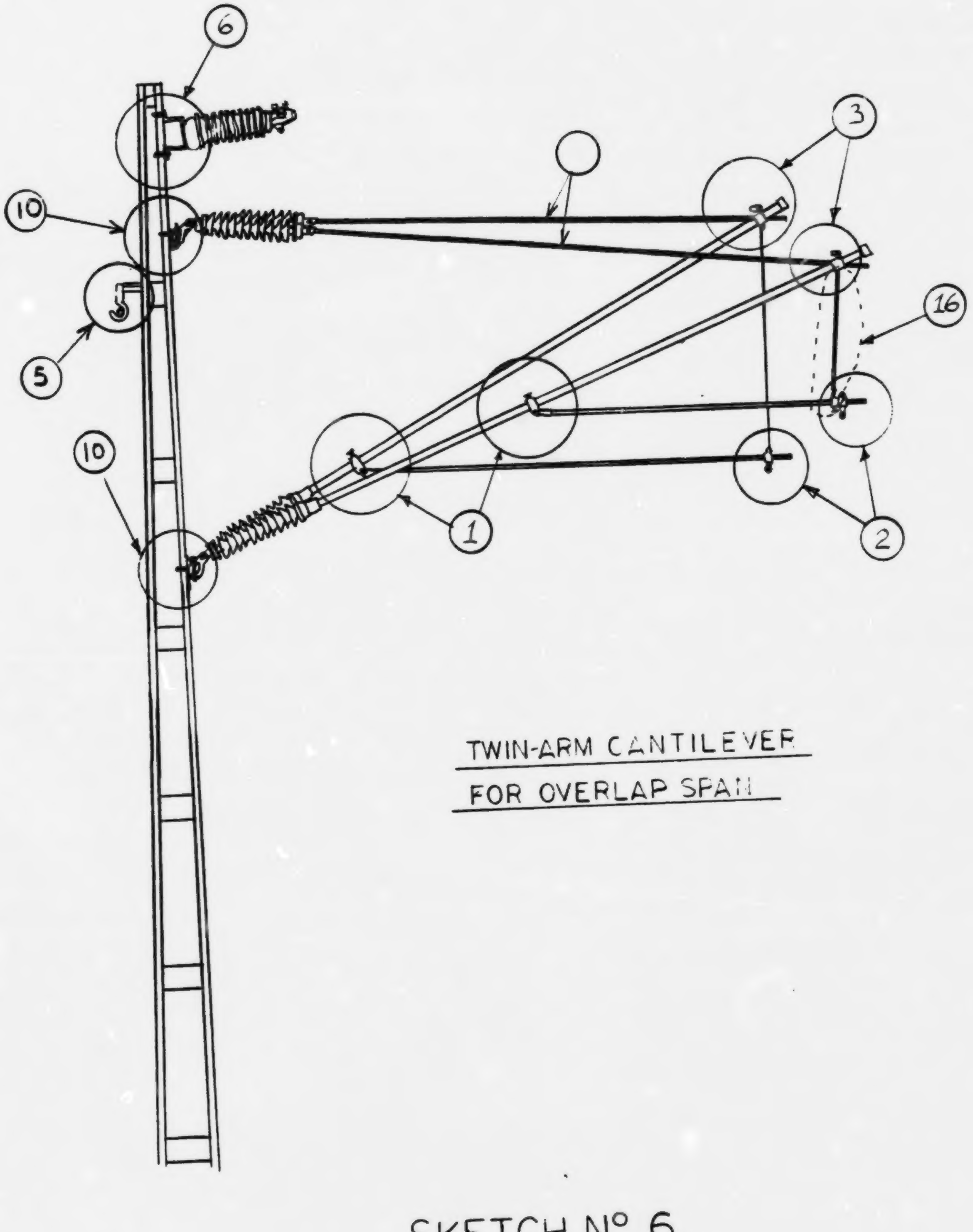
SINGLE CANTILEVER
IN INNER CURVE OF
RADIUS 291m., 349m.& 388m.

SKETCH N° 4



SINGLE CANTILEVER AT MID POINT ANCHOR

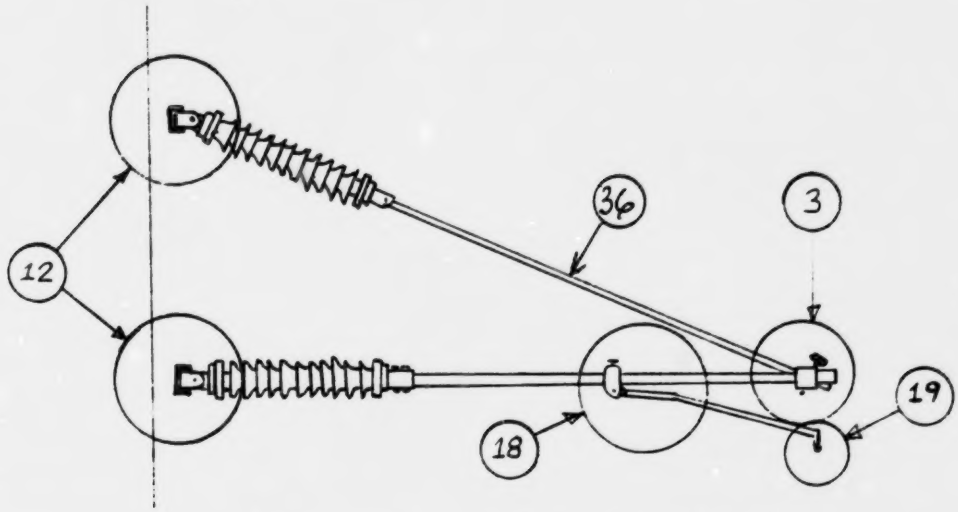
SKETCH N° 5


6
10
5
10
3
16
1
2

TWIN-ARM CANTILEVER
FOR OVERLAP SPAN

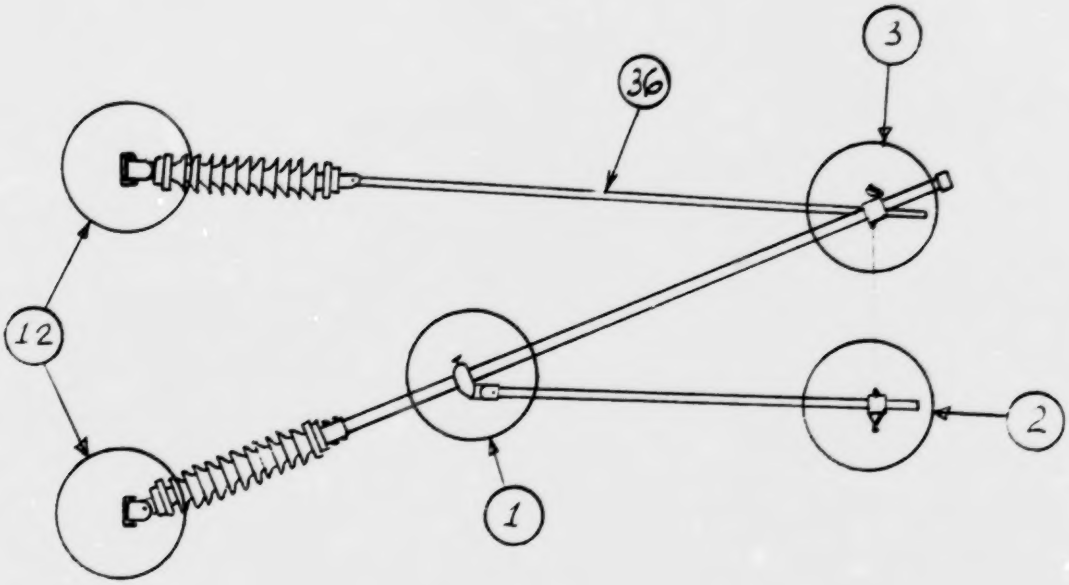
SKETCH N° 6

M.C.T. 821129



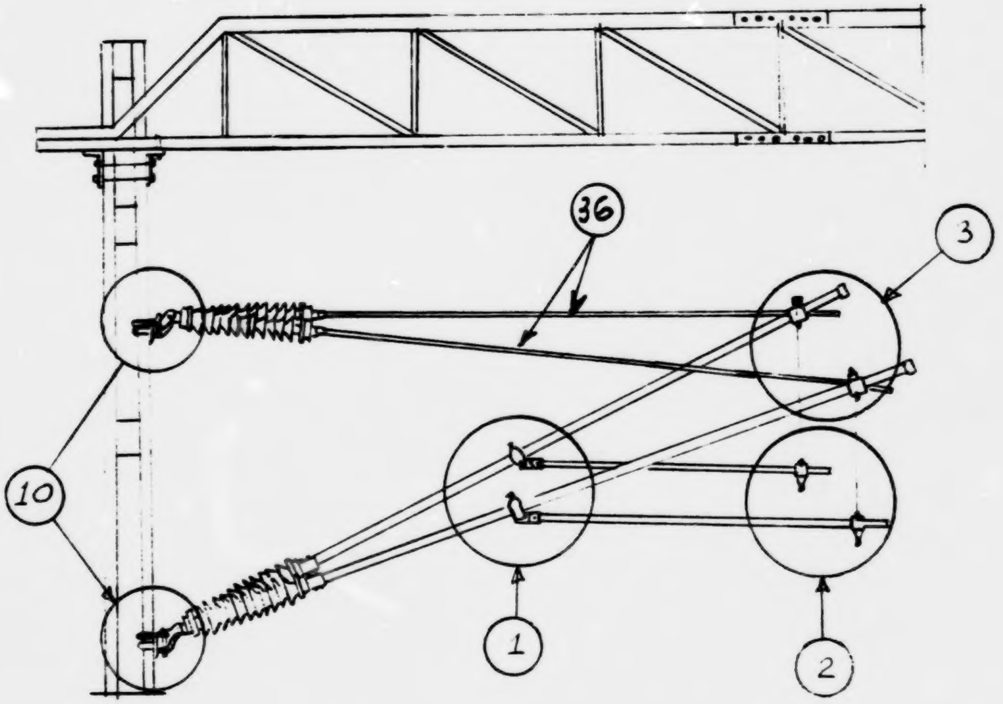
PARSNIP RIVER BRIDGE
CANTILEVER TYPE "B"

SKETCH N° 7



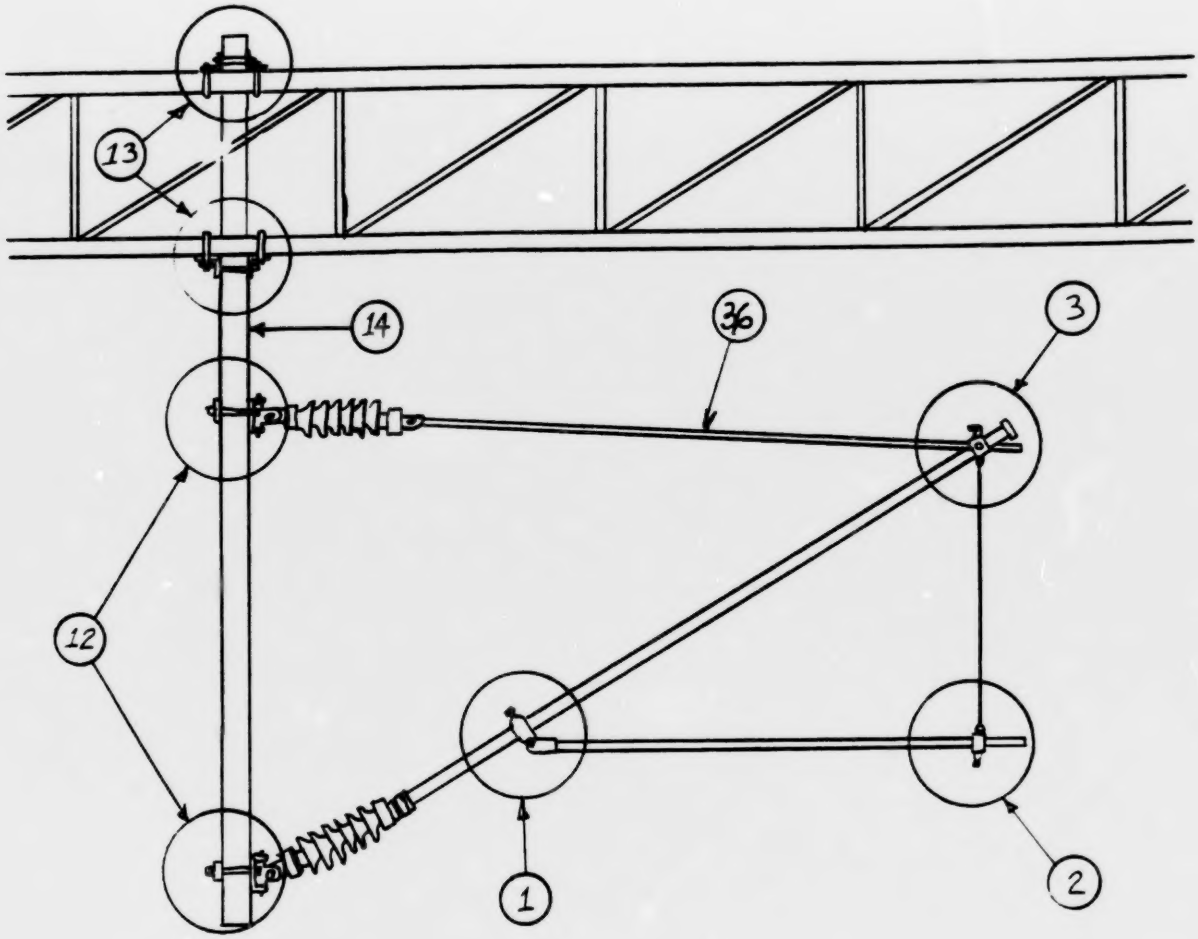
PARSNIP RIVER BRIDGE
CANTILEVER TYPE "A"

SKETCH N° 8



TWIN-ARM CANTILEVER FOR OVERLAP SPAN IN PORTAL OUTSIDE TRACK.

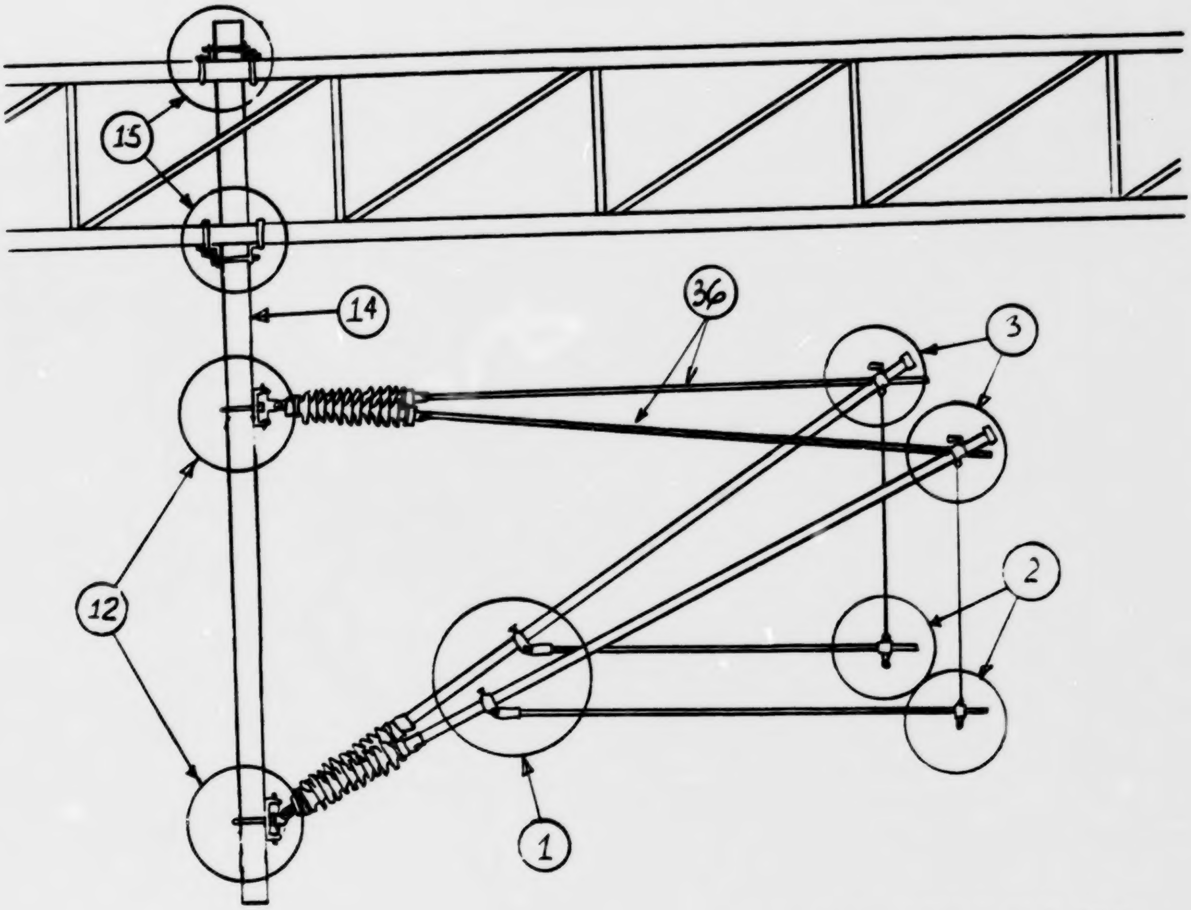
SKETCH N° 9


13
14
36
3
12
1
2

SINGLE CANTILEVER
PORTAL-CENTER TRACK

SKETCH N° 10

M.C.T. 821129

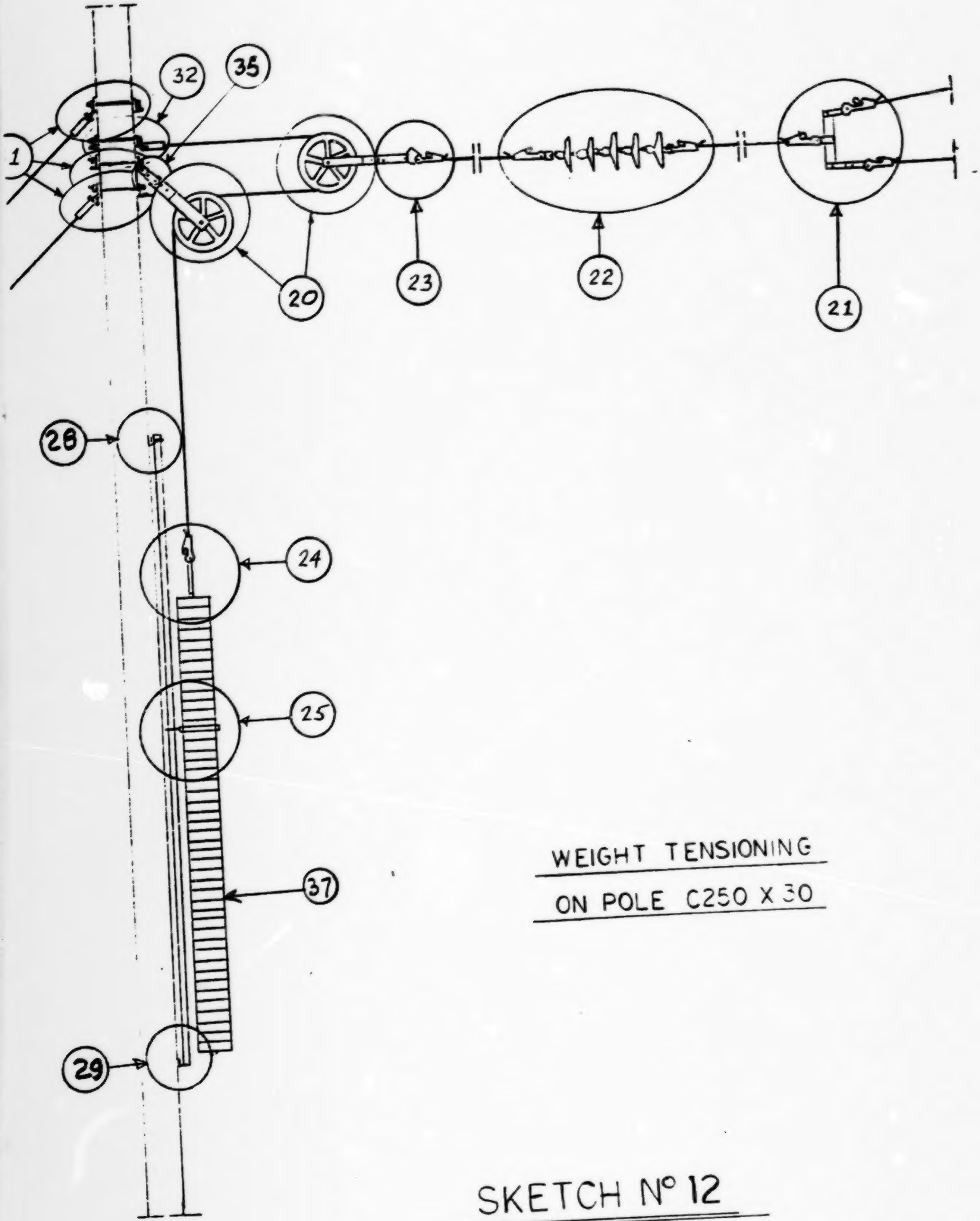

15
14
36
3
2
12
1

Two poles: each with its own cantilever

(2-503573)

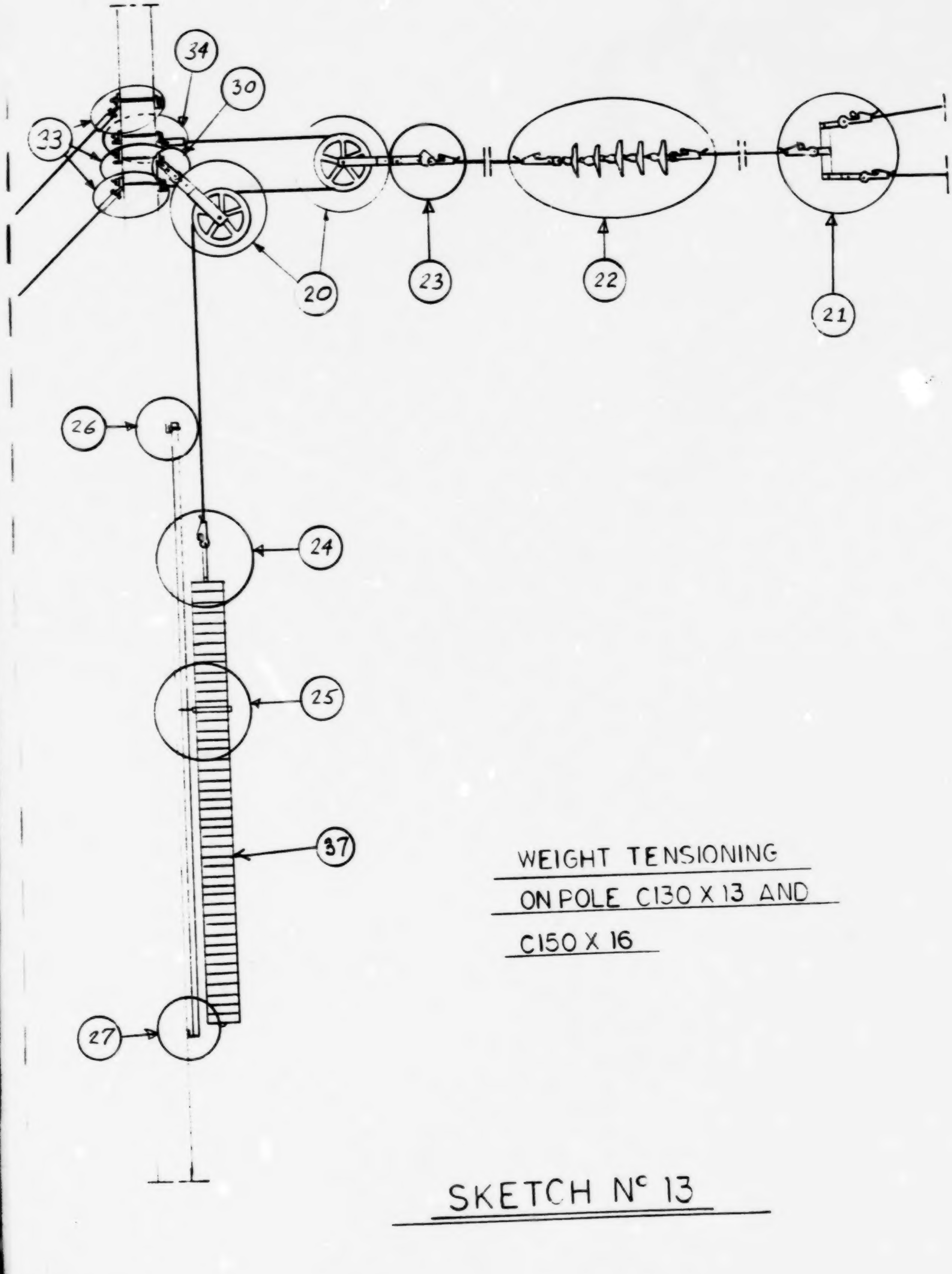
DOUBLE CANTILEVER FOR
OVERLAP SPAN IN PORTAL,
CENTER TRACK

SKETCH N° 11


32
35
1
20
23
22
21
28
24
25
37
29

WEIGHT TENSIONING
ON POLE C250 X 30

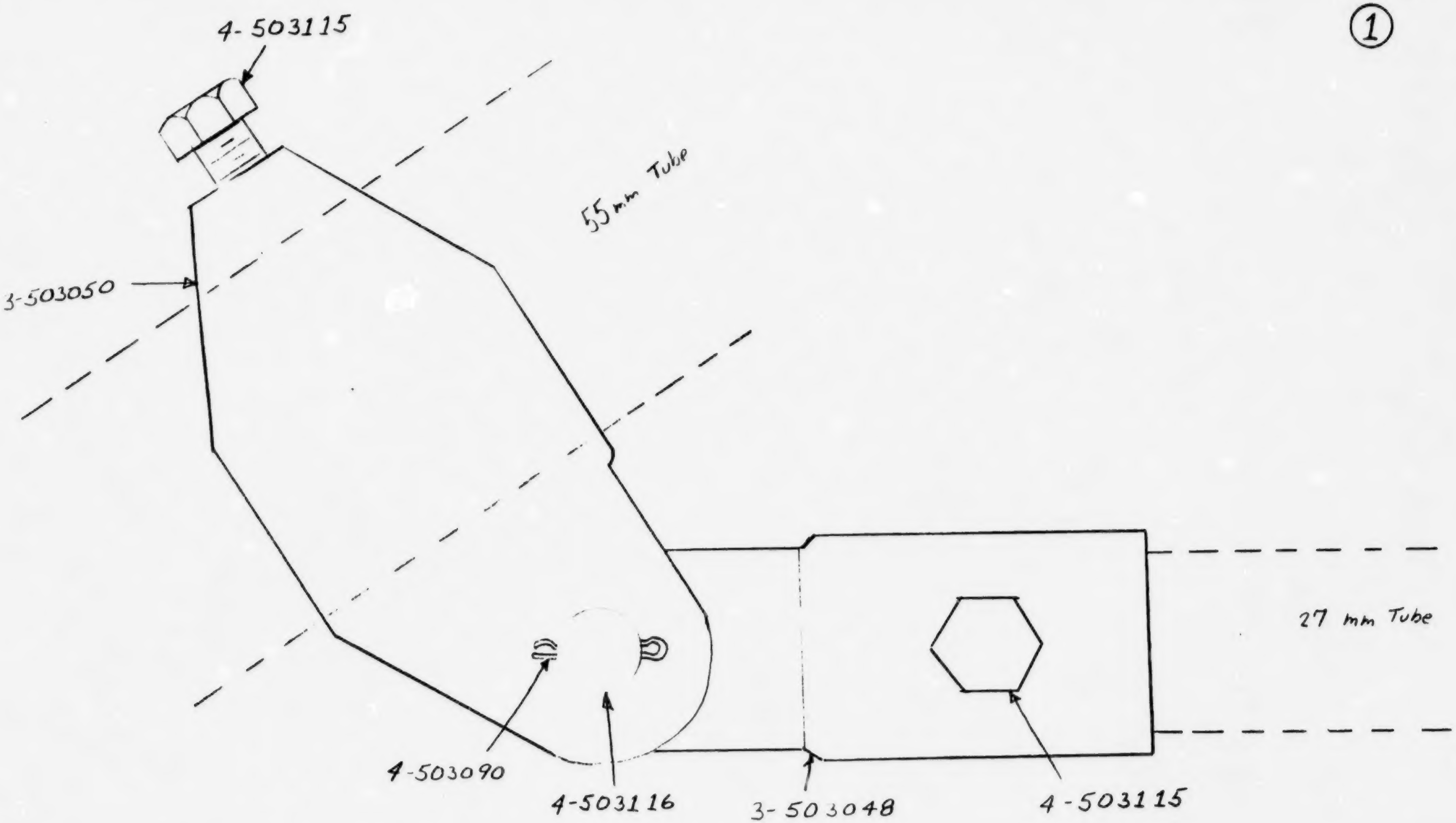
SKETCH N° 12


34
30
33
20
23
22
21
26
24
25
37
27

WEIGHT TENSIONING
ON POLE C130 X 13 AND
C150 X 16

SKETCH N^{c} 13

①

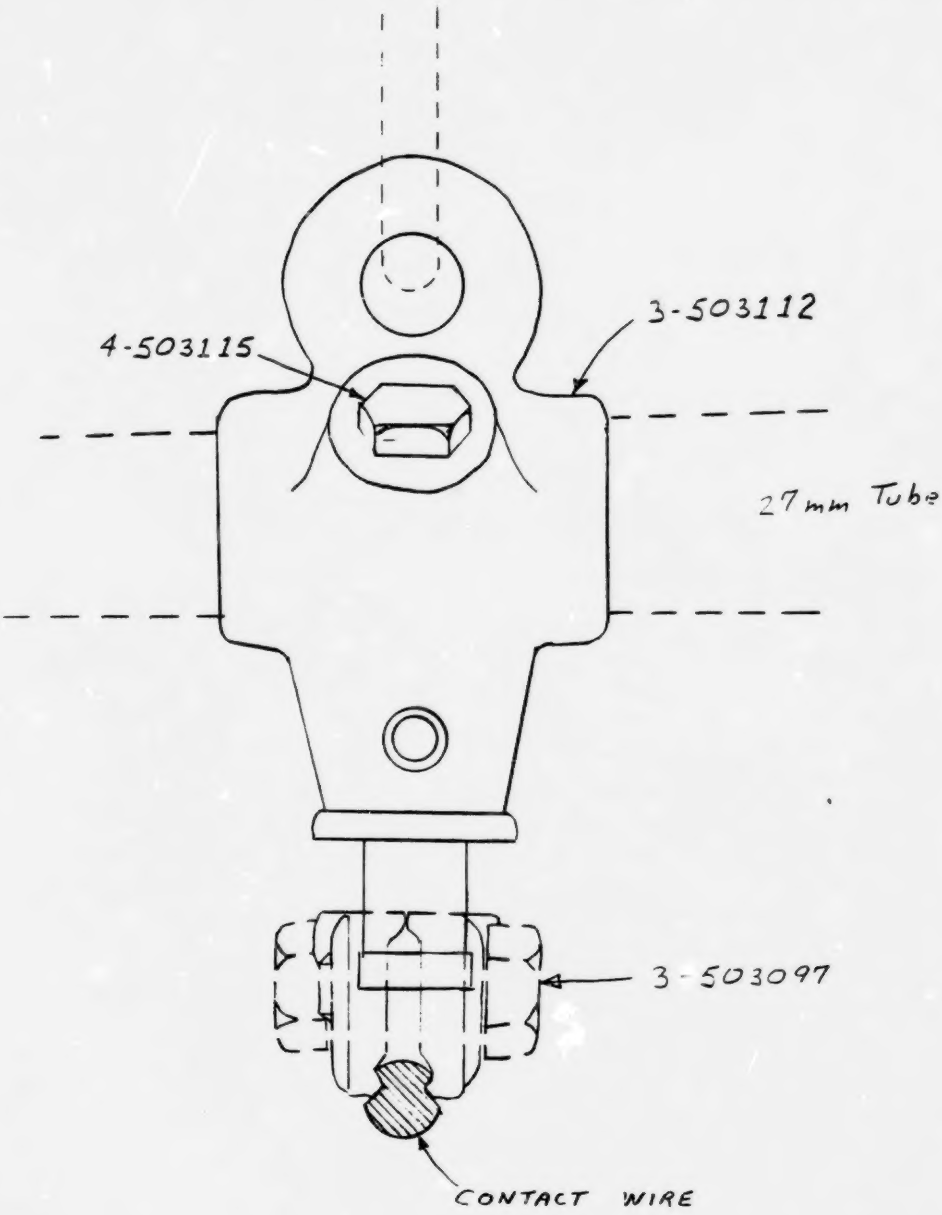

4-503115
55 mm Tube
3-503050
27 mm Tube
4-503090
4-503116
3-503048
4-503115

DRAWINGS

3-503050
3-503048
4-503115
4-503116
4-503090

SET Nº 1

M.C.T. 821116


3-503112
4-503115
27mm Tube
3-503097
CONTACT WIRE

DRAWINGS

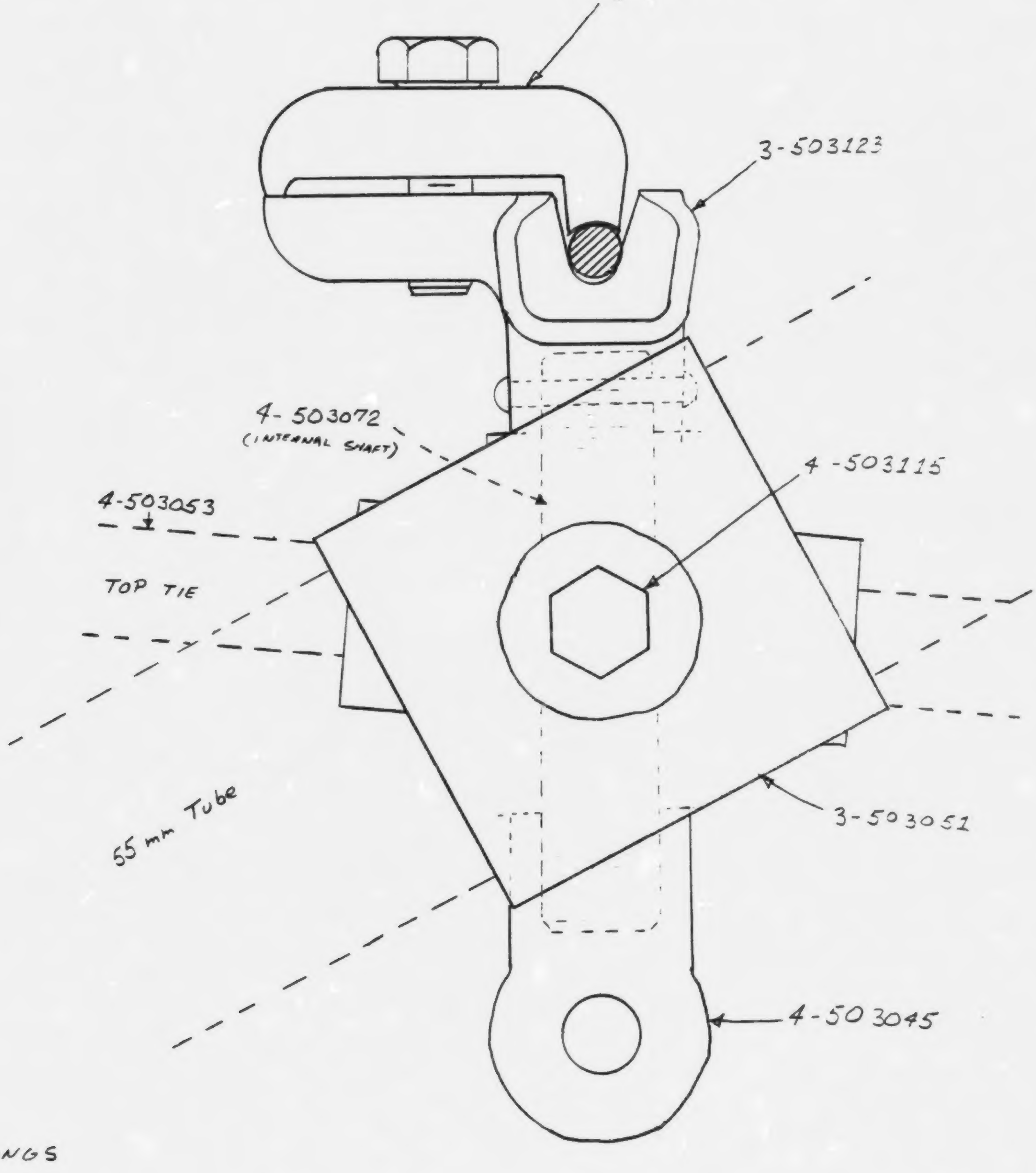
3-503112
4-503115
3-503097

SET N° 2

921116

M.C.T.

① ③


3-503124
3-503123
4-503072
(INTERNAL SHAFT)
4-503115
4-503053
TOP TIE
55 mm Tube
3-503051
4-503045

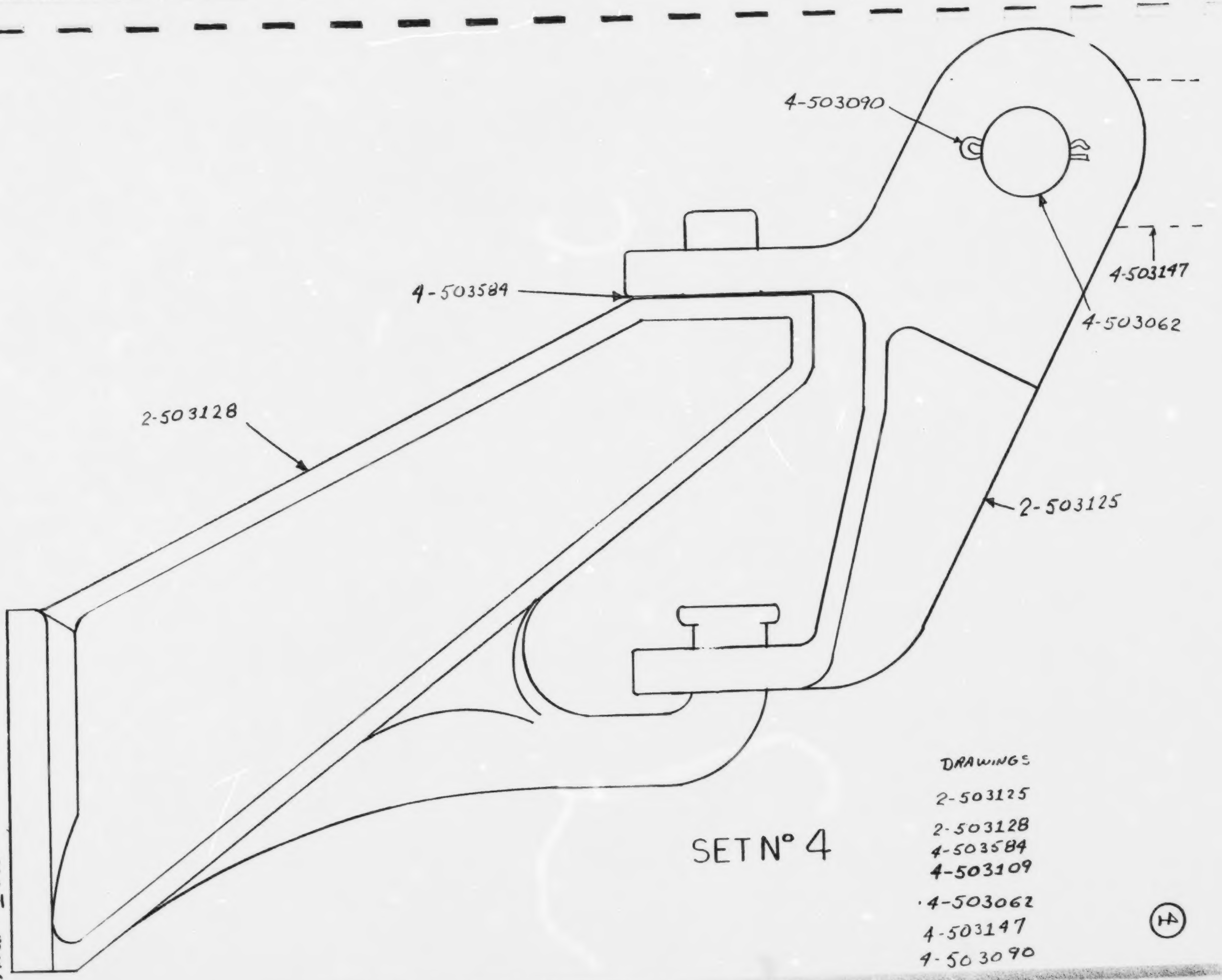
4-503115

DRAWINGS

3-503051
4-503045
4-503053
4-503115
4-503072
3-503123
3-503124
* 3-503076
} 4-503122

SET N°3

M.C.T. 921117


4-503090
4-503147
4-503062
4-503584
2-503128
2-503125

SET N° 4

DRAWINGS

2-503125

2-503128
4-503584
4-503109

·4-503062

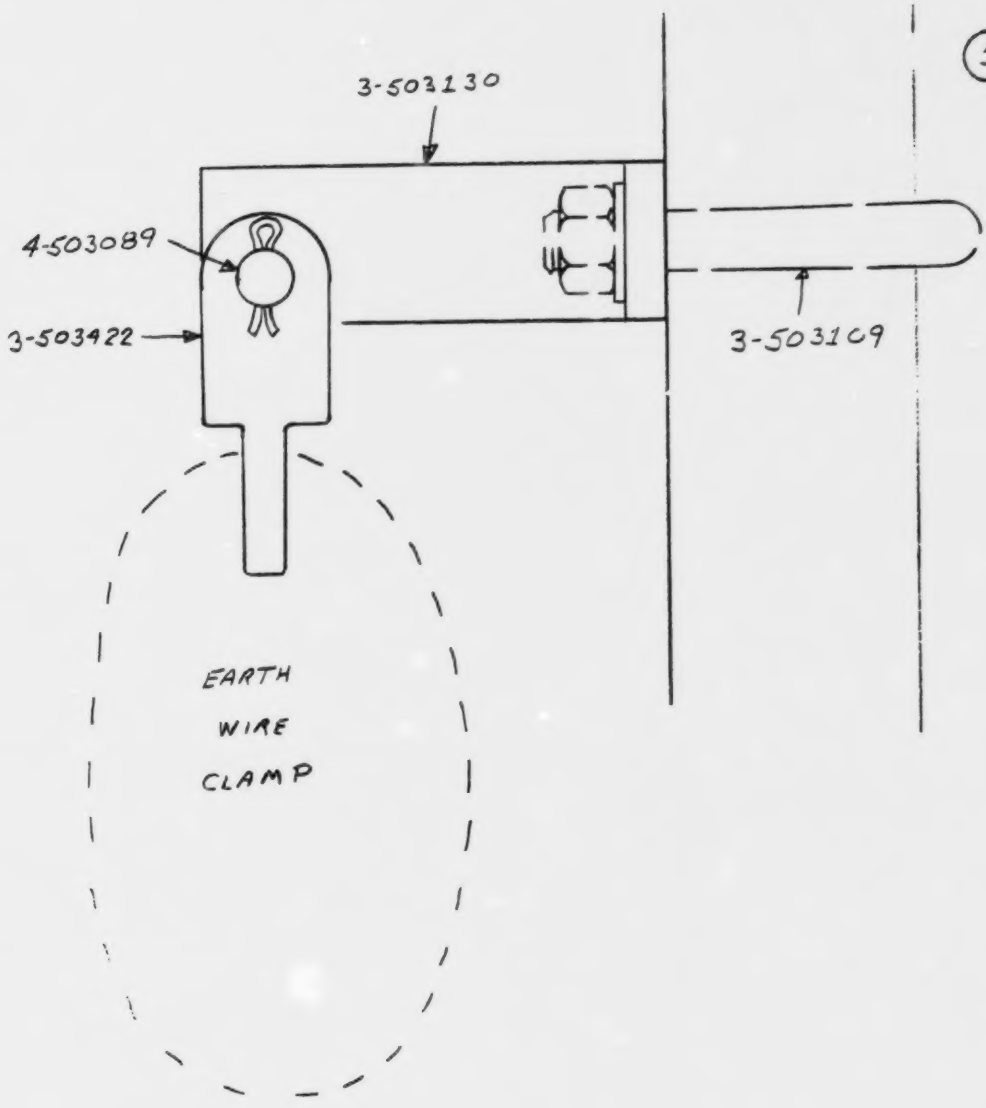
4-503147

4-503090

④

M.C.T. 821117

⑤


3-503130
4-503089
3-503422
3-503109
EARTH WIRE CLAMP

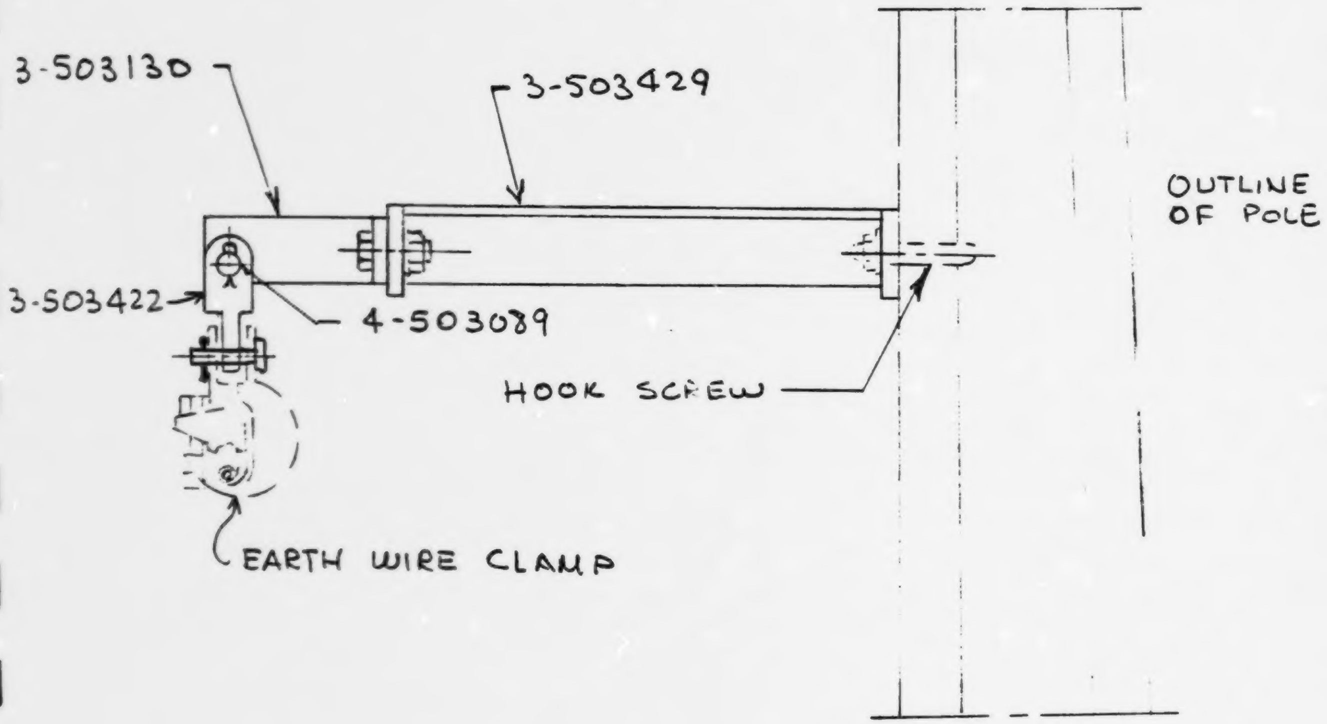
DRAWINGS

3-503130
3-503422
3-503109
4-503089

SET N° 5

M.C.T. 821117

5A

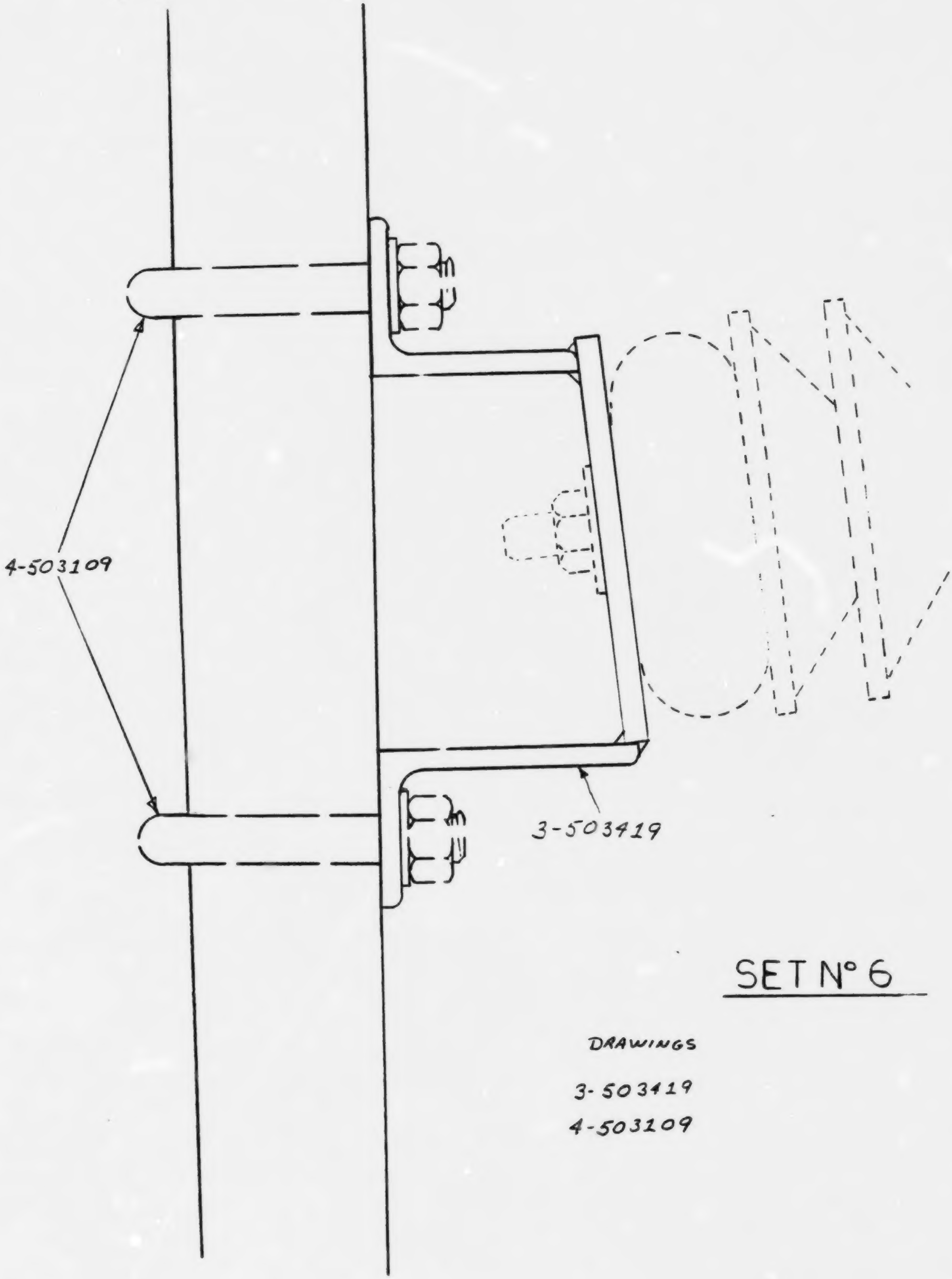

3-503130
3-503429
OUTLINE OF POLE
3-503422
4-503089
HOOK SCREW
EARTH WIRE CLAMP

DRAWING
3-503130
3-503422
3-503429
3-503089

SET N° 5A

R1 321215

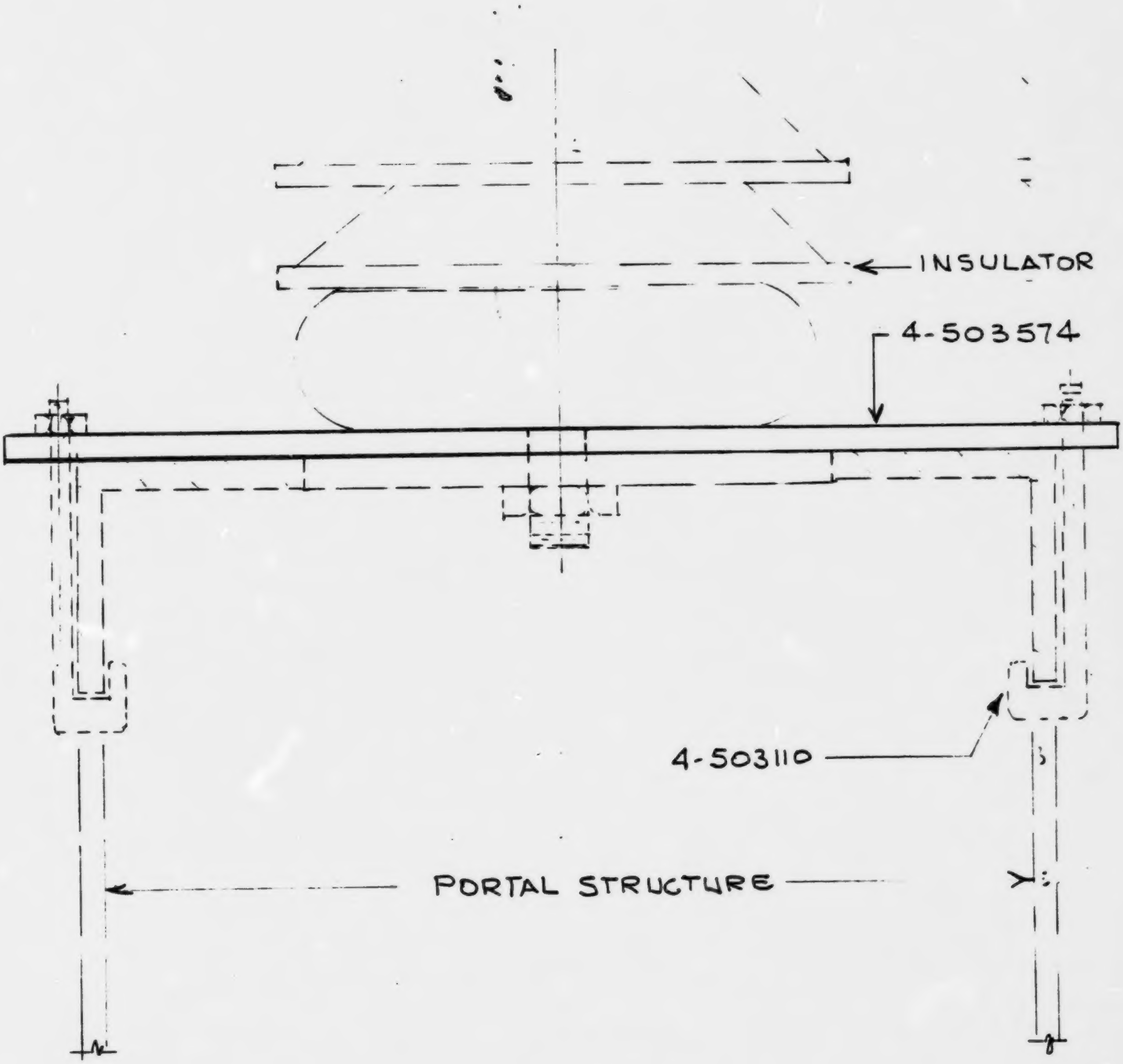
⑥


4-503109
3-503419

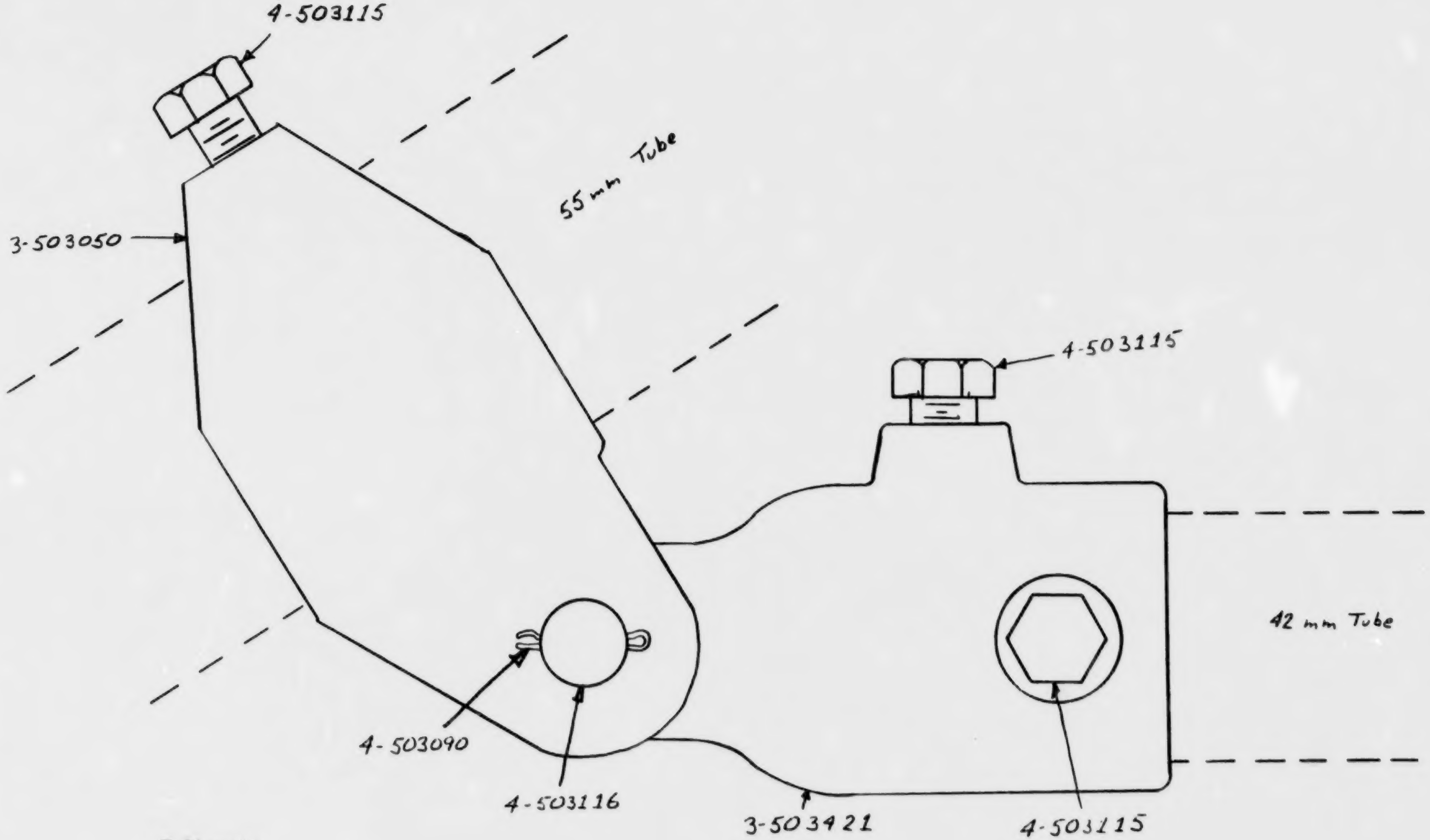
SET N° 6

DRAWINGS

3-503419
4-503109


INSULATOR
4-503574
4-503110
PORTAL STRUCTURE

SET N° 6A


4-503115
55 mm Tube
3-503050
4-503115
42 mm Tube
4-503090
4-503116
3-503421
4-503115

SET N° 7

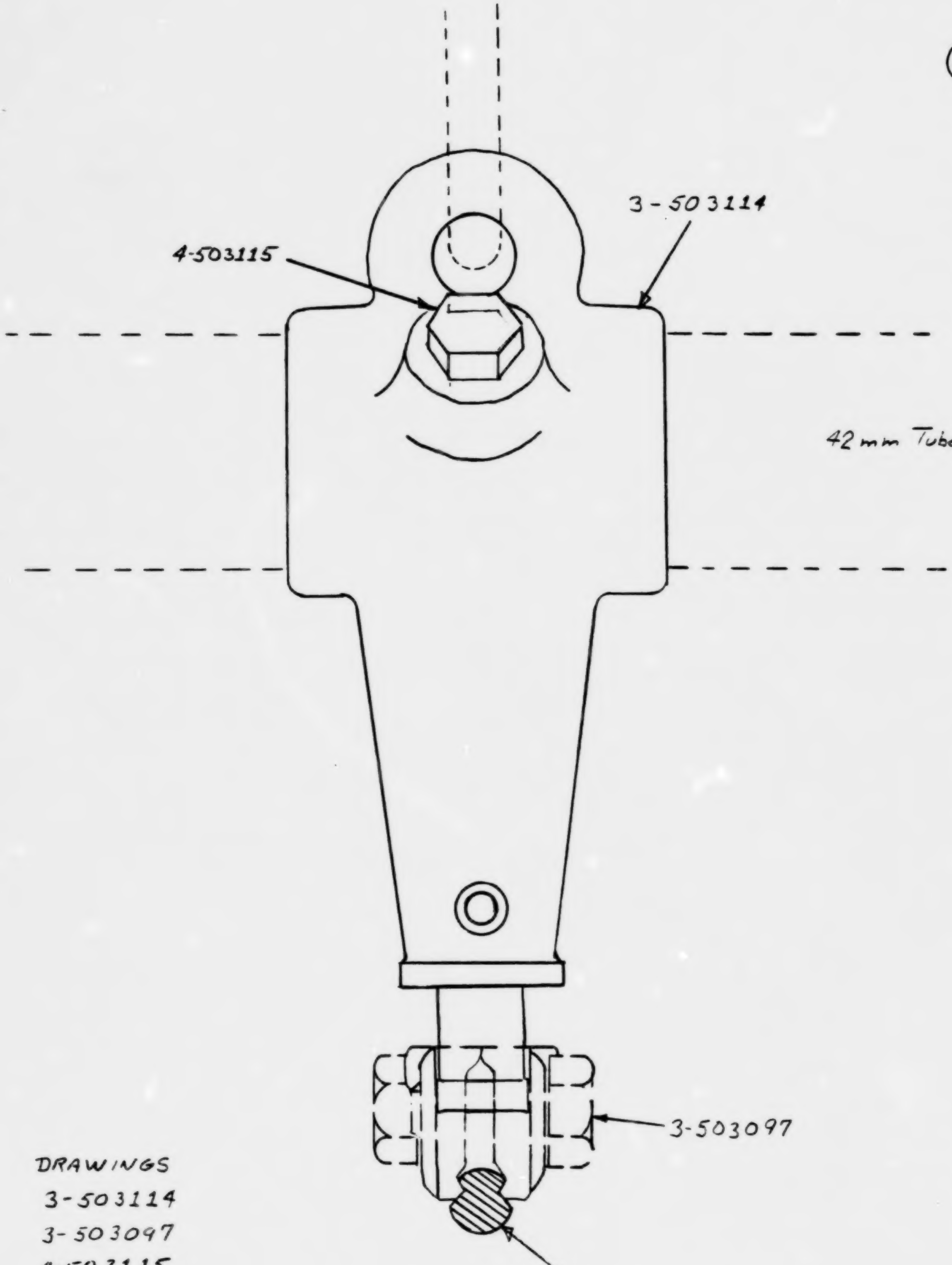
DRAWINGS

3-503050
3-503421
4-503115
4-503116
4-503090

M.C.T. 1821118

⑦

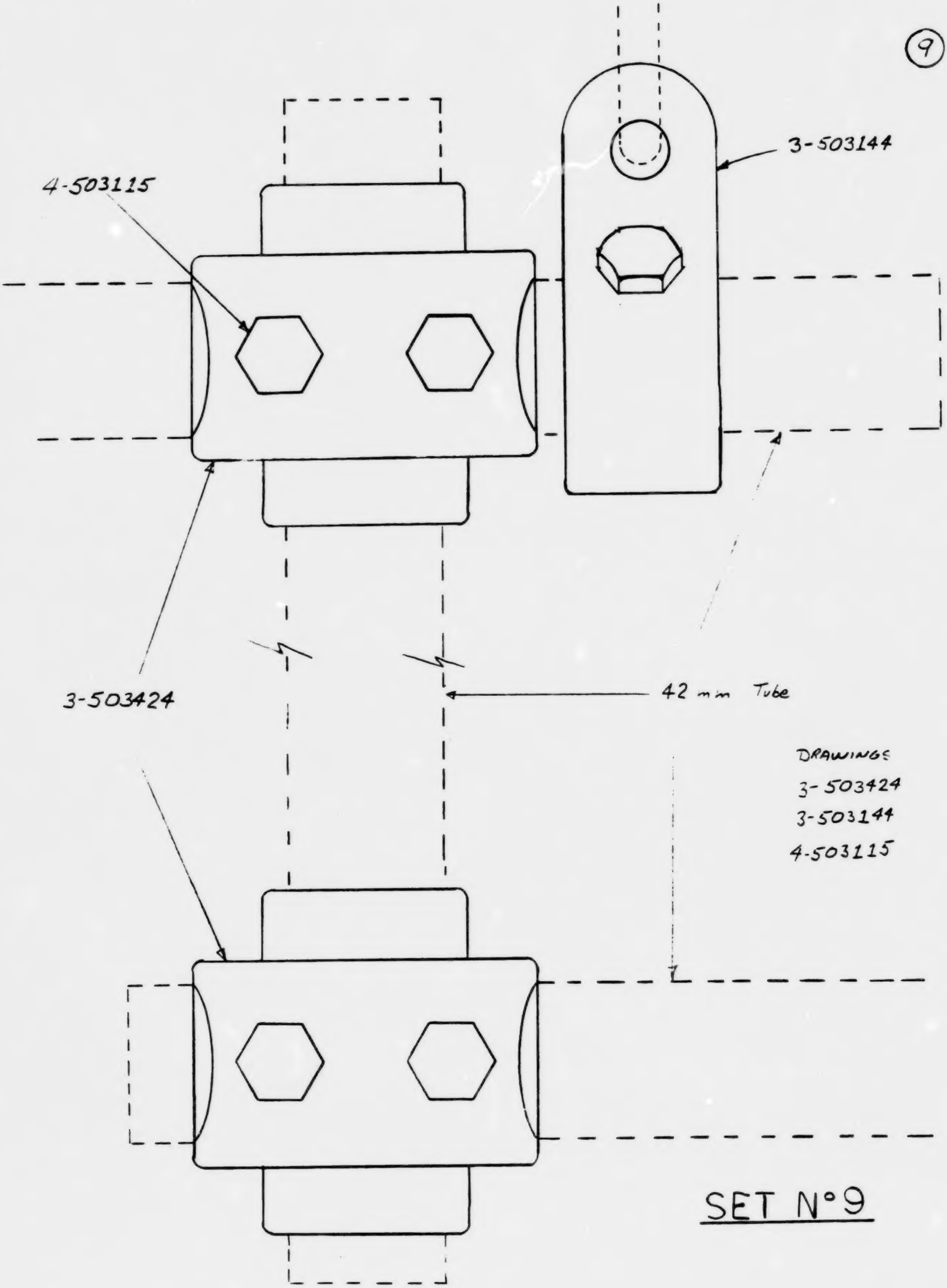
⑧


3-503114
4-503115
42 mm Tube
3-503097
CONTACT WIRE

DRAWINGS
3-503114
3-503097
4-503115

SET N°8

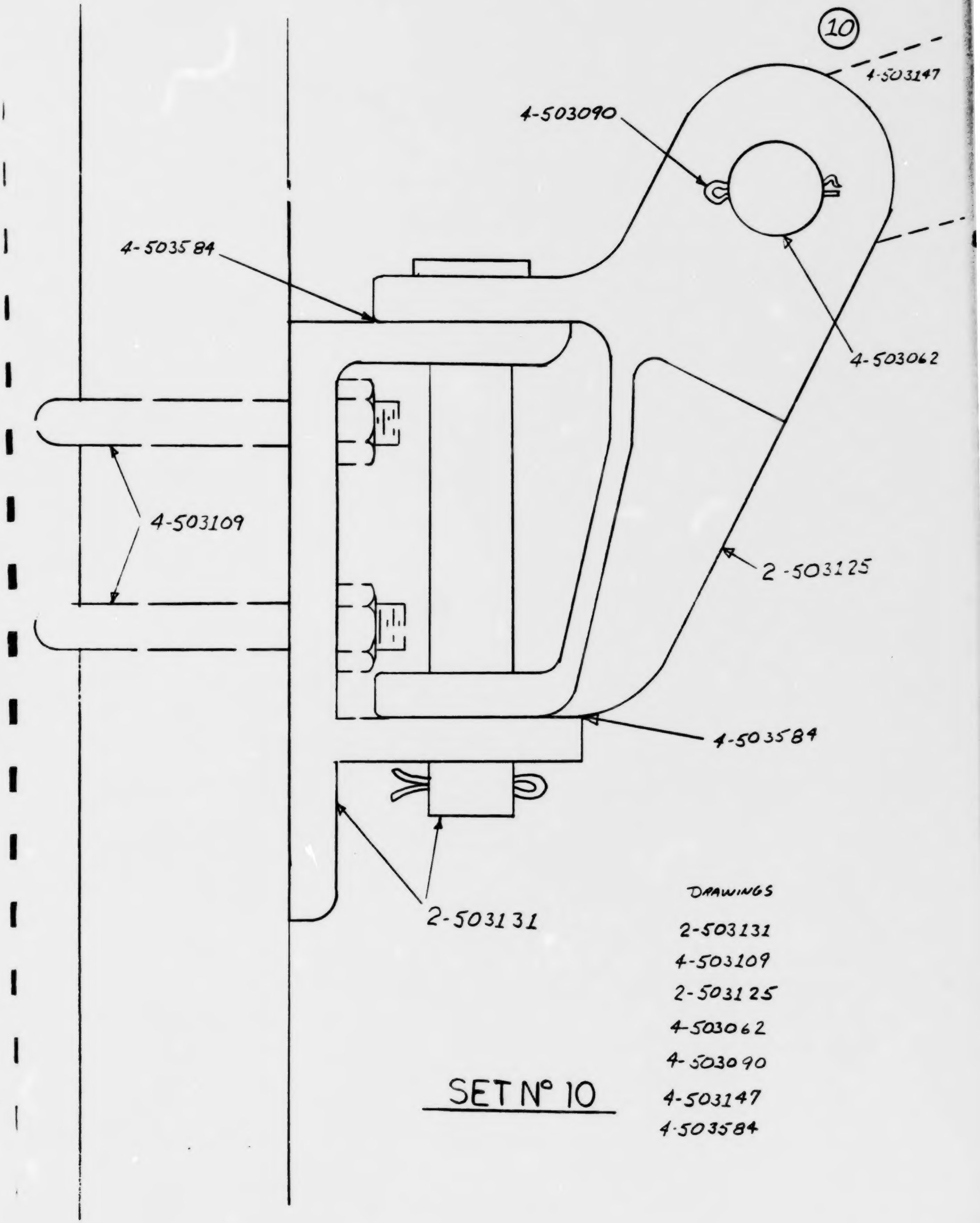
⑨


4-503115
3-503144
3-503424
42 mm Tube

DRAWINGS
3-503424
3-503144
4-503115

SET N°9

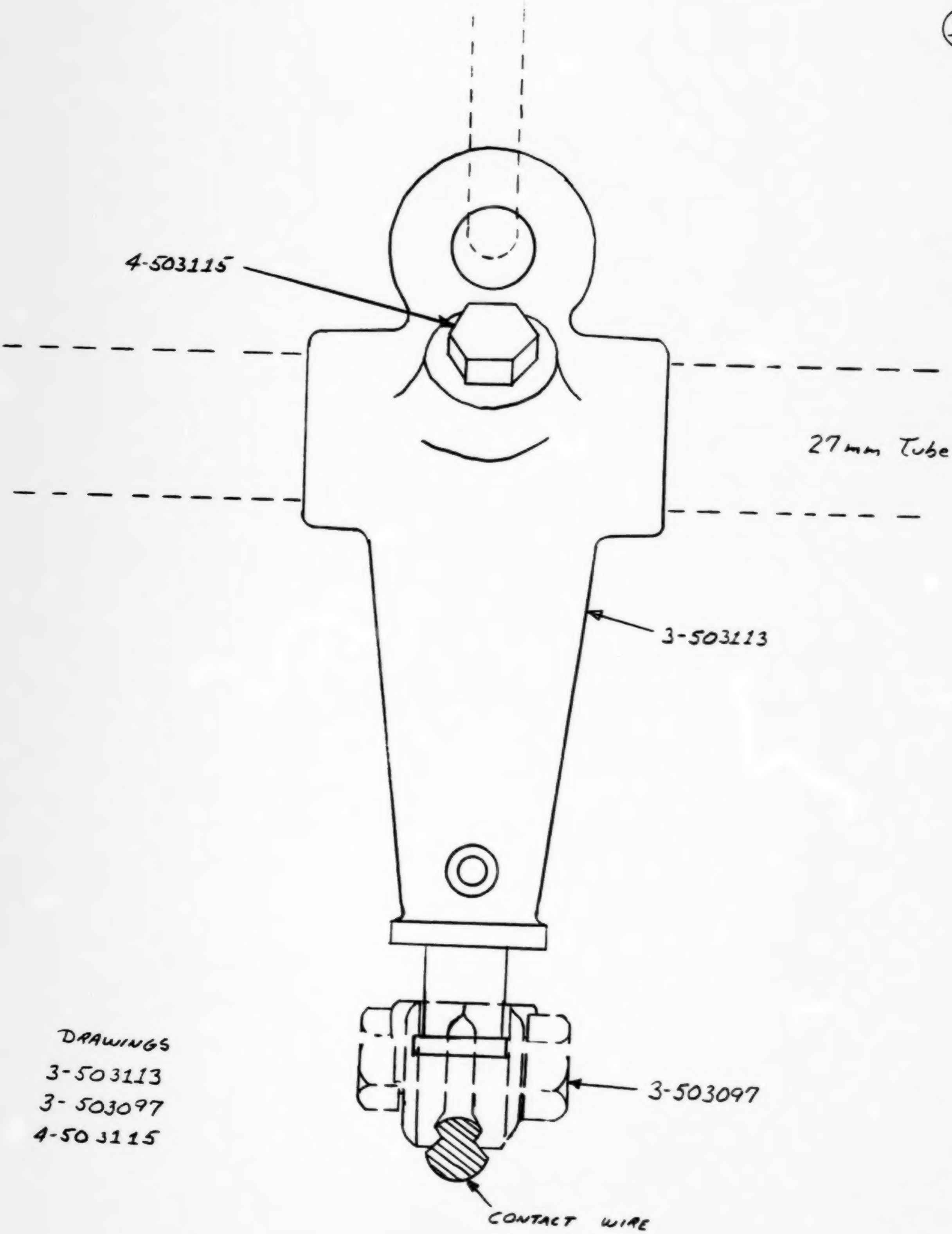
⑩


4-503147
4-503090
4-503584
4-503062
4-503109
2-503125
4-503584
2-503131

SET N° 10

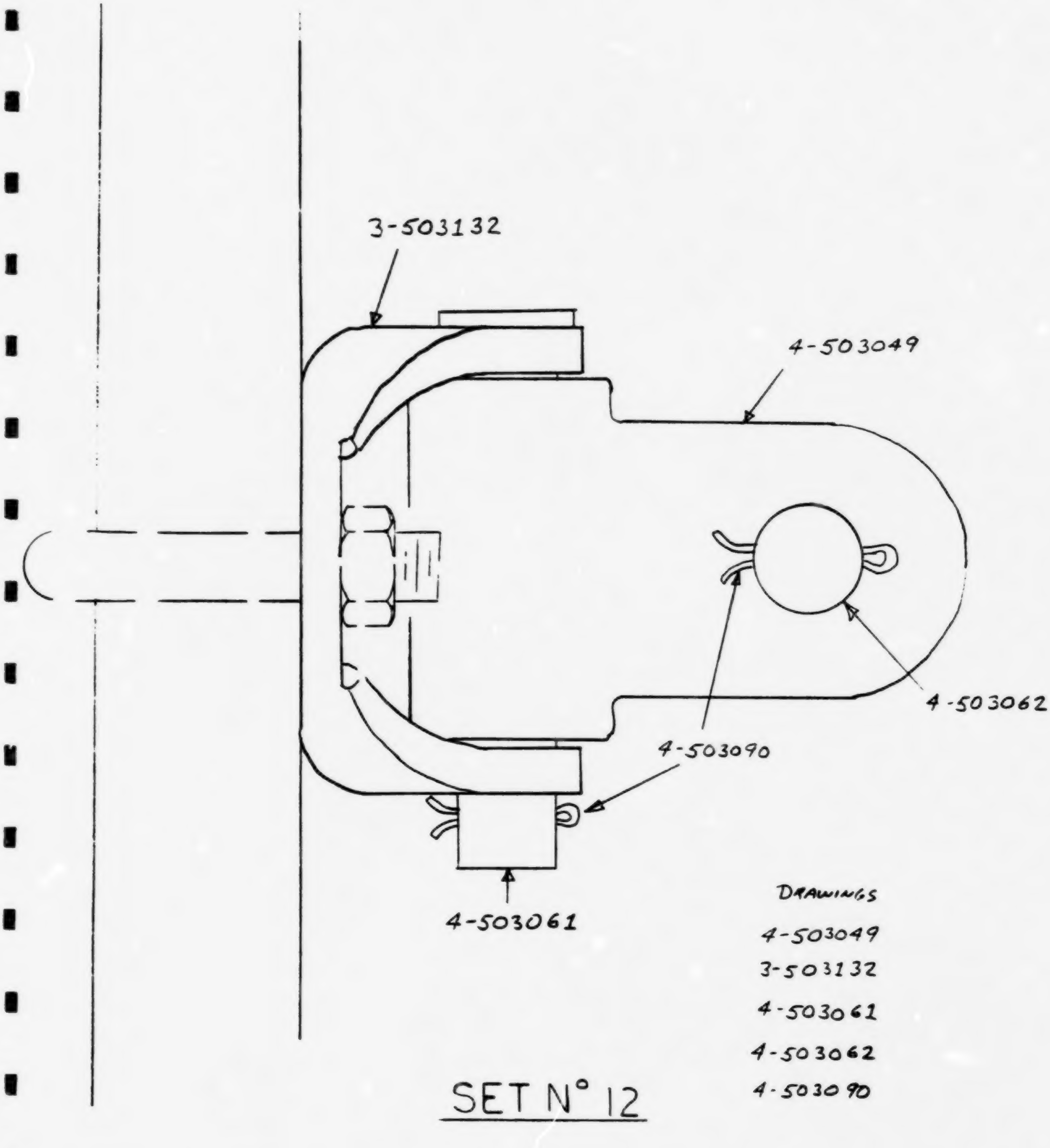
DRAWINGS

2-503131
4-503109
2-503125
4-503062
4-503090
4-503147
4-503584


4-503115
27mm Tube
3-503113
3-503097
CONTACT WIRE

DRAWINGS
3-503113
3-503097
4-503115

SET N° 11


3-503132
4-503049
4-503062
4-503090
4-503061

DRAWINGS
4-503049
3-503132
4-503061
4-503062
4-503090

SET N° 12

⑬

SET N° 13

Refer to Drawing No. 4-503416

(17)

SET N°14

Refer to Drawing No. 3-503064

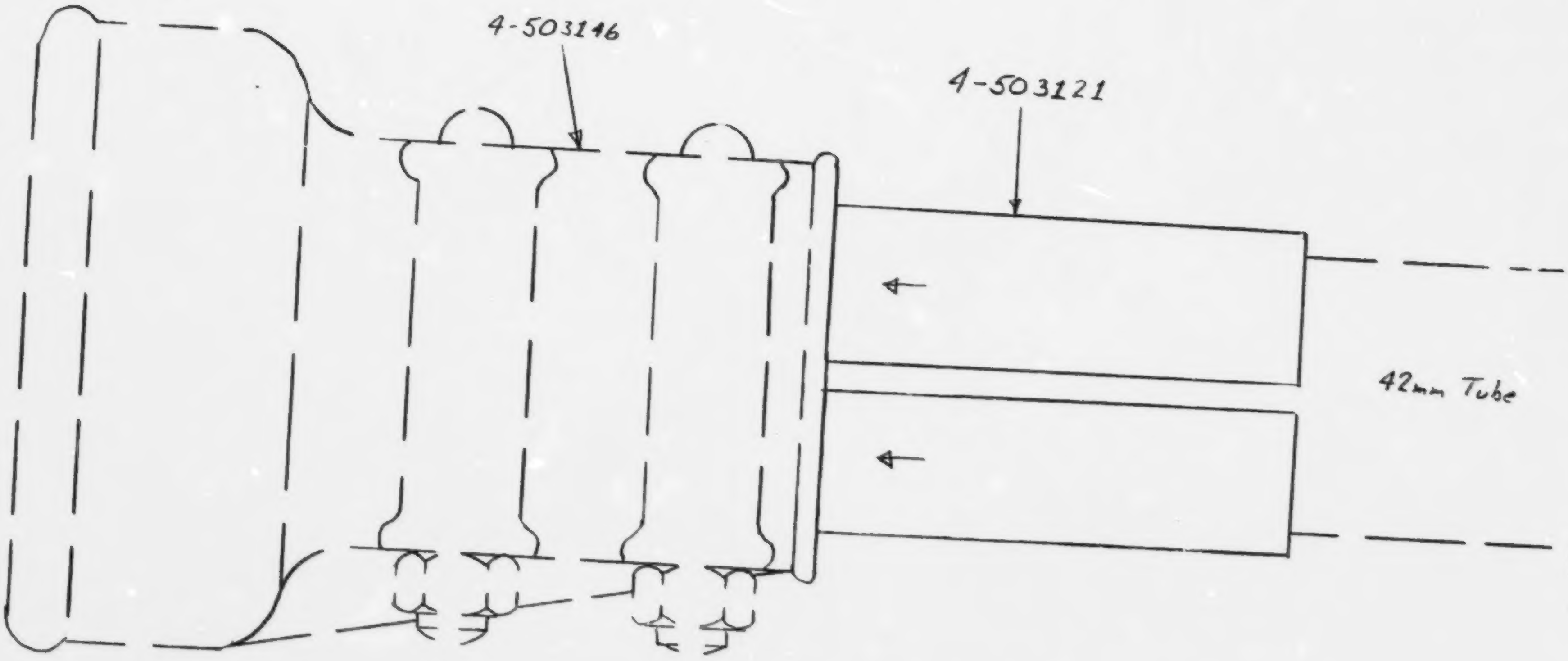
⑮

SET N° 15

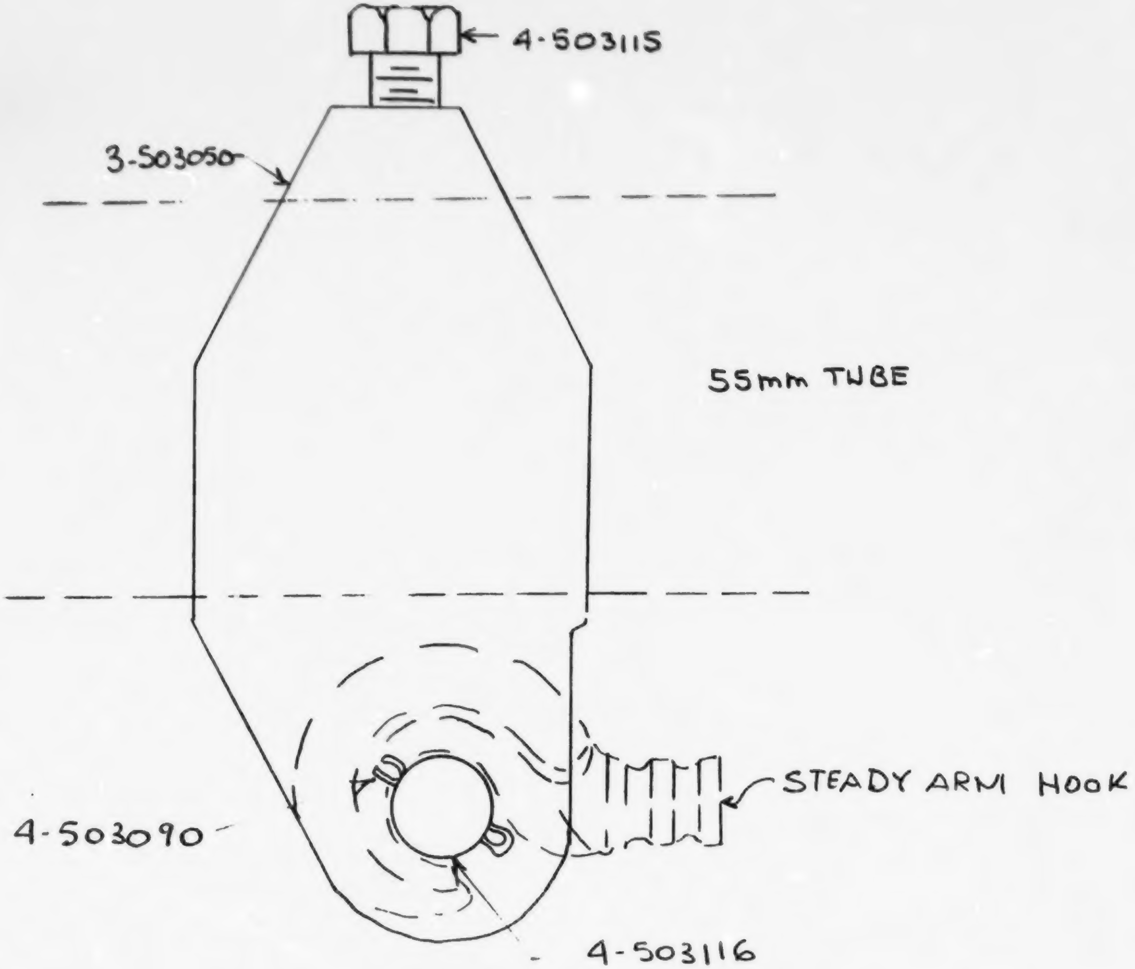
Refer to Drawing No. 4-503575

SET Nº 16

Refer to Drawing No. 4-503572
4-503274


4-503146
4-503121
42mm Tube

SET N° 17

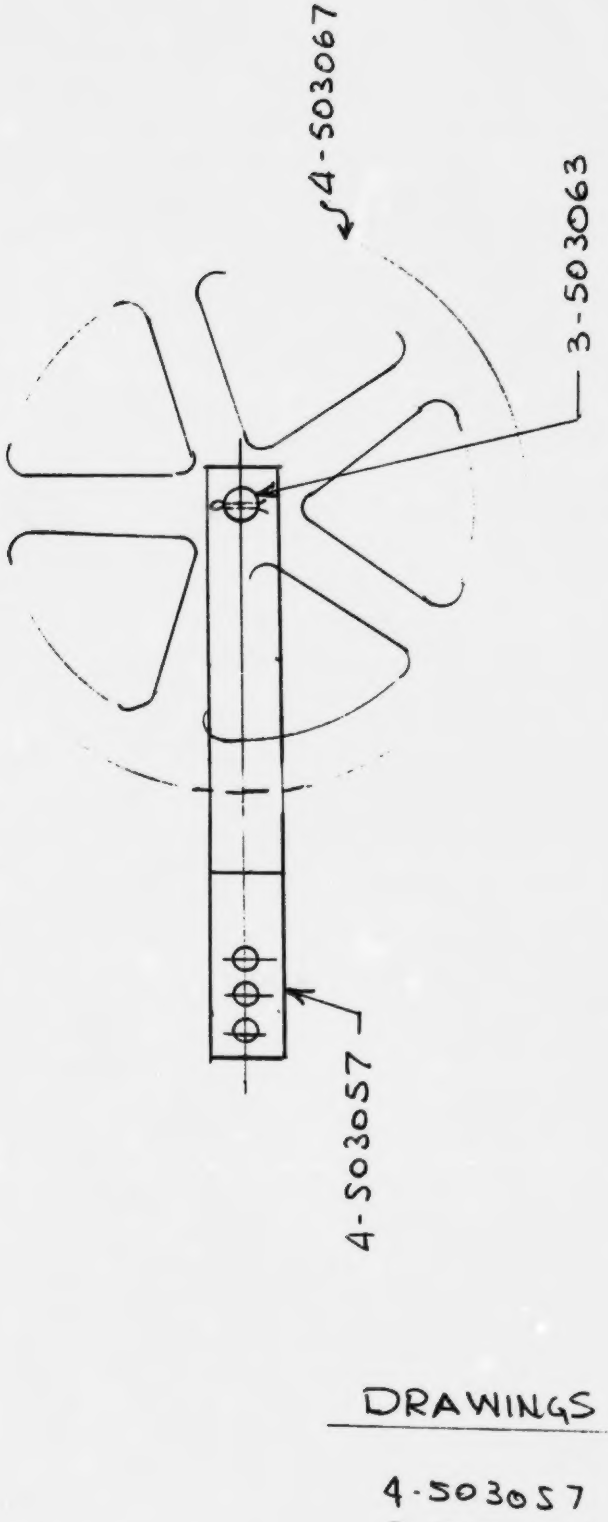

4-503115
3-503050
55mm TUBE
STEADY ARM HOOK
4-503090
4-503116

SET N° 18

⑲

SET N° 19

Refer to Drawing No. 3-503662


4-503067
3-503063
4-503057

DRAWINGS

4-503057
3-503063
4-503067

SET N°20

㉑

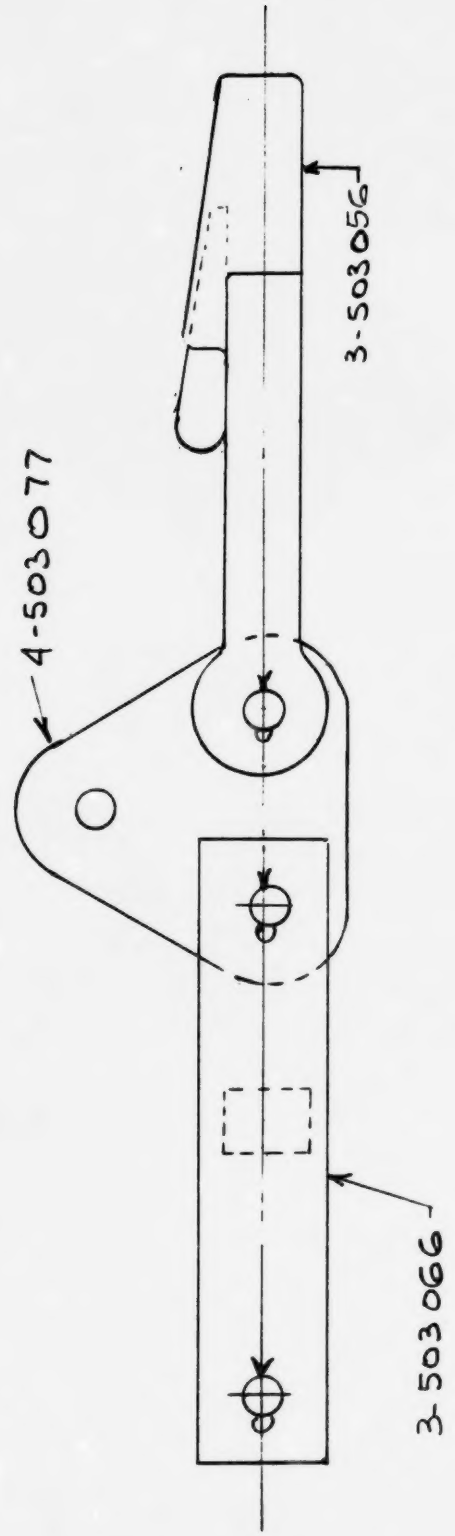
SET N°21

Refer to Drawing 3-503286

㉒

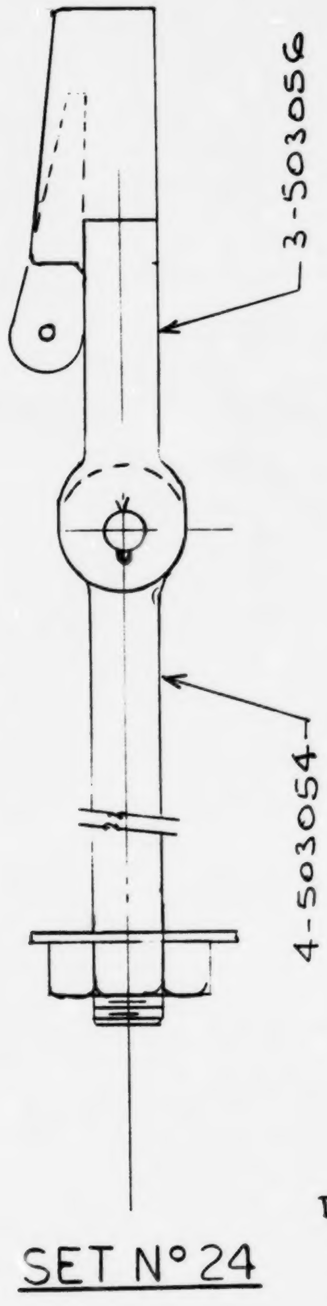
SET N° 22

Refer to Drawing 3-503428


3-503056
4-503077
3-503066

SET N° 23

DRAWING
3-503066
3-503056
4-503077


3-503056
4-503054

SET N° 24

DRAWING
3-503056
4-503054

(25)

SET N° 25

Refer to Drawing 3-503046

(26)

SET N° 26

Refer to Drawing 2-503285

27

SET N° 27

Refer to Drawing 2-503285

28

SET N° 28

Refer to Drawing 2-503656

29

SET N° 29

Refer to Drawing 2-503656

㉚

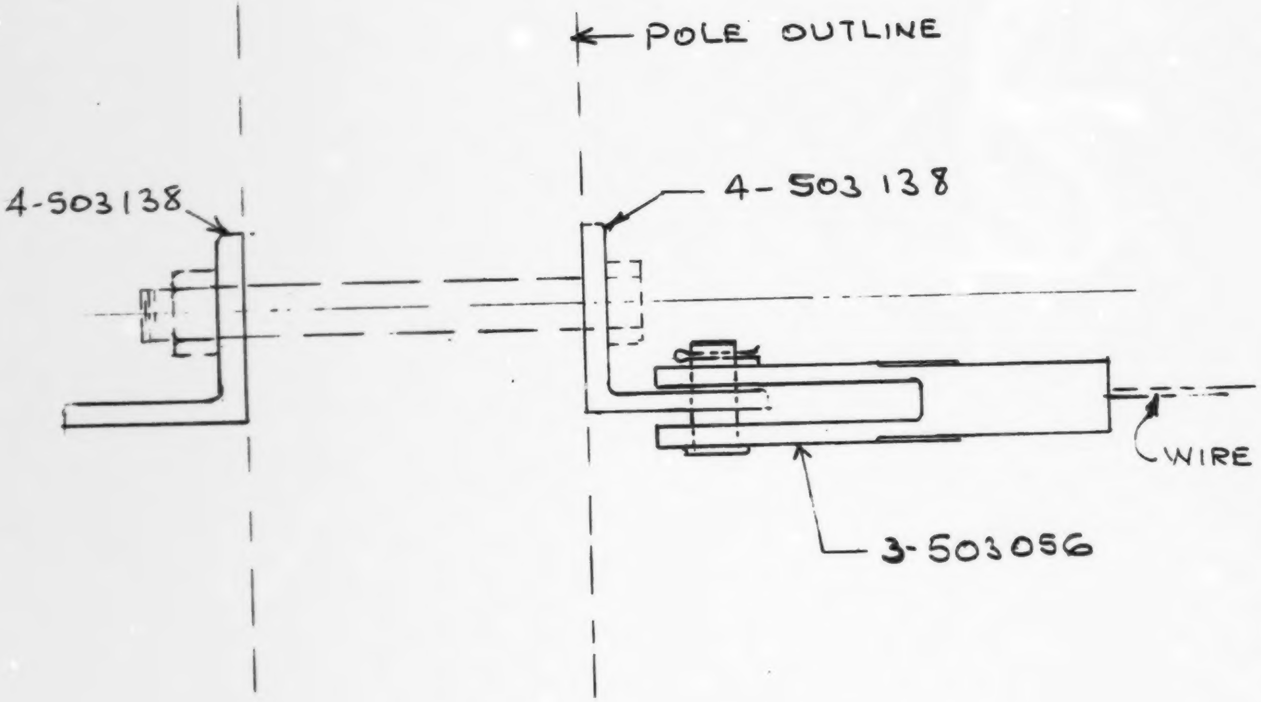
SET N° 30

Refer to Drawing 2-503285

31

SET N° 31

Refer to Drawing 3-503133

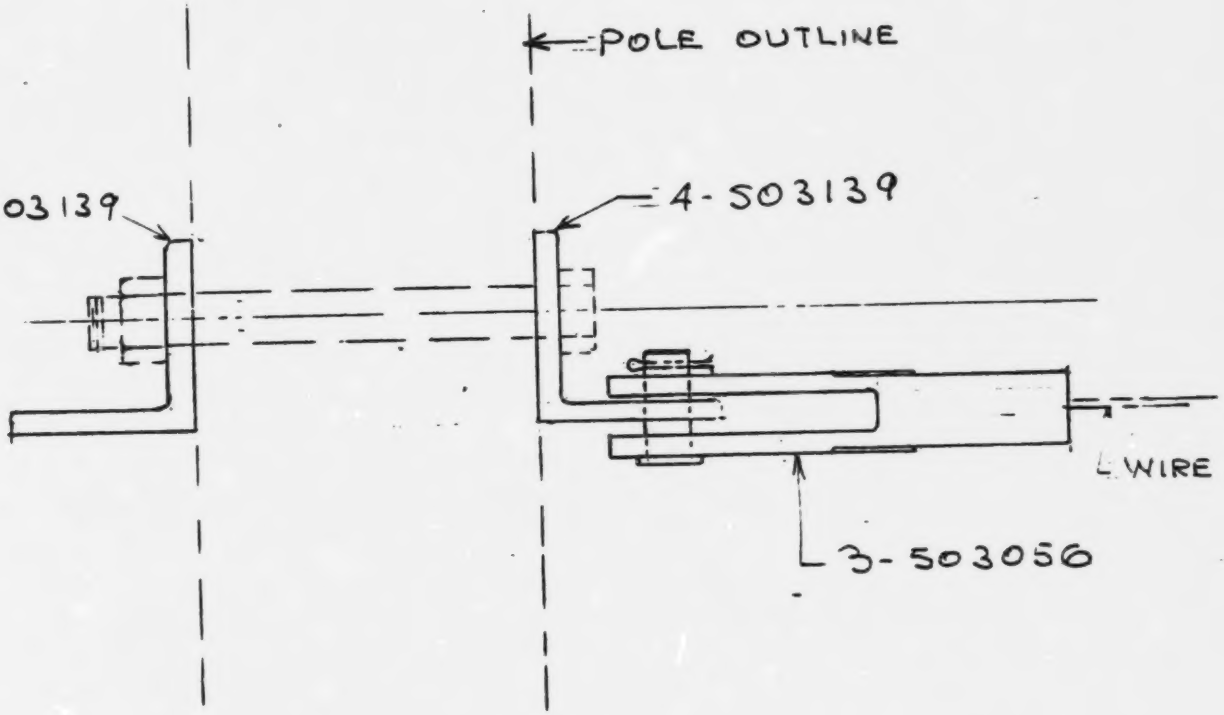

POLE OUTLINE
4-503138
4-503138
3-503056
WIRE

SET N° 32

33

SET N° 33

Refer to Drawing 3-503657


POLE OUTLINE
4-503139
4-503139
WIRE
3-503056

SET N° 34

35

SET N° 35

Refer to Drawing 2-503656

③⑥

SET N° 36

Refer to Drawing 4-503053

37

SET N° 37

Refer to Drawing 3-503111

Portal Structure Specification

PORTAL STRUCTURE SPECIFICATION
FOR
BRITISH COLUMBIA RAILWAYS
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES LTD.
MONTREAL, QUE.
REVISED March 2, 1983

PORTAL STRUCTURE SPECIFICATION

1. SCOPE

1.1 The British Columbia Railway is electrifying its Tumbler Ridge branch line, a route distance of some 130 kilometres for 50 kV 60 Hz operation. Sketch A attached shows the project location.

1.2 This specification covers the fabrication, testing and delivery of portal structure members required for supporting the overhead wiring in multi track sections.

2. APPLICABLE STANDARDS

2.1 The following standards apply in whole or in part to the various members and components.

STANDARD	TITLE
CSA CAN3-G40.20M81	General requirements for rolled or welded structural quality steel
CSA CAN3-G40.21-M81	Welded steel construction (metal Arc Welding)
CSA G164-1965	Hot dip galvanizing of irregularly shaped articles
ASTM A325-74	High strength bolts for structural steel joints including suitable nuts and plain hardend washers.

3. DETAILED REQUIREMENTS & QUANTITIES

The folliwng is a description and quantities of the bridge portions of portal structures required to support the overhead equipment in multi track sections.

* Quantities of small components include 5% for spares and wastage. Quantities of the larger, fabricated members are the number required.

SET NO.	DRAWING NO.	DESCRIPTION	QUANTITY
90	4-503082	Joint set no. 90	
		per drawing 3-503085	215*
		per drawing 4-503084	215*
		per drawing 4-503083	215*
97	4-503091	Joint set no. 97	
		per drawing 3-503094	215*
		per drawing 4-503093	215*
		per drawing 4-503092	215*
54	3-503107	Console	280*
55	3-503108	Crossbar	280*
50	4-503109	Hookscrew 3/4 UNC x 110 0414.003-4	1,700*
51		Screw 3/4 UNC x 8 in.	300*
52		Screw M20 x 50 mm c/w wax nut per drawing 4-503095	8,500*
53	4-503136	Head of attachment	300*
	2-503117	End Structure (0410504 L = 4,000 mm)	131
	2-503117	End structure (0410505 L = 5,000 mm)	3
2-503119	Intermediate structure (0410523 L = 3,000 mm)		67
2-503119	Intermediate structure (0410526 L = 6,000 mm)		67

4. ACCEPTANCE TESTS

The supplier shall demonstrate compliance with the requirements of this specification and other referenced standards to the engineer or his designated representative.

5. SHIPPING AND HANDLING

5.1 Large sections shall be delivered as single units. Smaller components shall be packaged in reasonable quantities for manual handling.

5.2 Sections shall be clearly identified by drawing number and length. Packages of components shall be marked as to identify clearly its contents and quantity.

5.3 Delivery to the British Columbia Railway location will be specified in the purchase order and shall begin as soon as possible after February 28, 1983 and shall be 50% completed by April 16, 1983 and 100% completed by May 10, 1983.

6. INFORMATION REQUIRED WITH TENDER

The bidders shall submit the following information when tendering.

6.1 State if your tender complies in every respect (yes or no) with this specification.

6.2 Principal product line

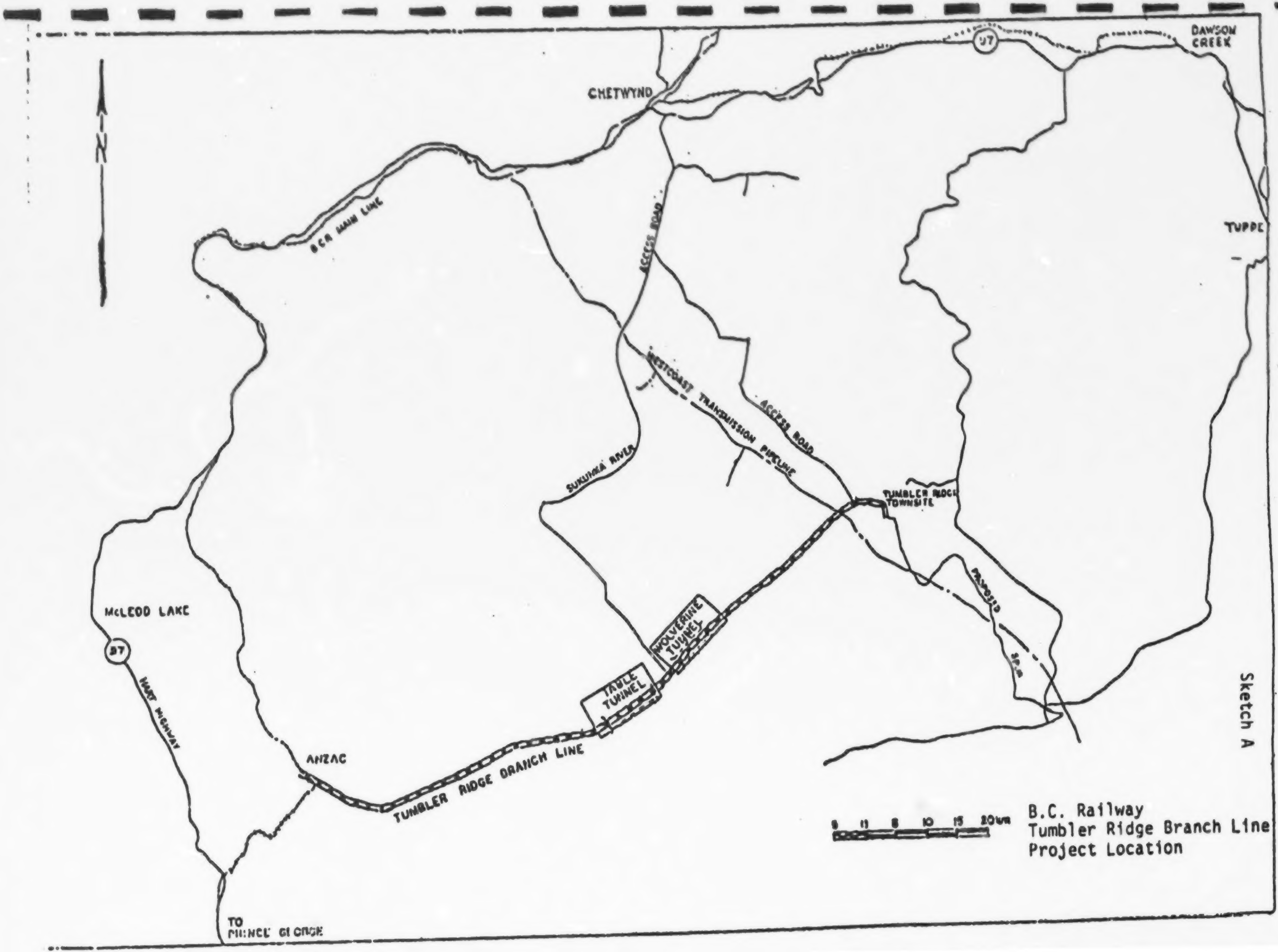
6.3 Annual volume of sales

6.4 Annual volume of sales in product line described in this specification.

6.5 No. of people employed:
   a) professionals;
   b) skilled labour;
   c) non skilled labour.

6.6 Attach description and location of manufacturing facilities.

Sketch A


DAWSON CREEK
TUPPER
97
CHETWYND
BCR MAIN LINE
ACCESS ROAD
WESTCOAST TRANSMISSION PIPELINE
ACCESS ROAD
SUKUNKA RIVER
TUMBLER RIDGE TOWNSITE
PROPOSED SPUR
WOLVERINE TUNNEL
TABLE TUNNEL
TUMBLER RIDGE BRANCH LINE
ANZAC
McLEOD LAKE
97
HART HIGHWAY
TO PRINCE GEORGE
N
0 5 10 15 20km

B.C. Railway
Tumbler Ridge Branch Line
Project Location

Insulator Specification

INSULATOR SPECIFICATION

1. SCOPE

The British Columbia Railway is electrifying its Tumble Ridge Branch Line, a route distance of some 130 kms, for 50 kV 60 Hz operations.

This specification covers the design (where necessary), the manufacture, factory testing and delivery of insulators required for the overhead system. Types of insulators and their quantities are itemized as follows:

			Quantity
Item 1	-	Rod Insulators Drawing 2-503149	200 units
Item 2	-	Rod Insulators Drawing 2-503150	2900 units
Item 3	-	Rod Insulators Drawing 2-503272	2900 units
Item 4	-	Suspension Insulators	650 units of 5
Item 5	-	Station Post Insulators	375 units
Item 6	-	Line Post Insulator	110 units

2. SERVICE CONDITIONS

The insulators will be installed in a remote, mountainous region at elevations from 760 to 1160 metres.

The atmosphere is expected to be clean except in the tunnels where coal dust pollution can occur.

Only the suspension insulators of Item 4 and the station post insulators of Item 5 will be installed in the tunnels.

Temperatures will vary from minus 45^{o}C in the winter to plus 45^{o}C in the summer.

Tunnel temperatures will vary from the exterior values at the portals and from 13^{o}C to 18^{o}C in the interiors.

Exterior loading conditions per CSA Standard C22.3 No. 1-M1979 are classified: as heavy at 12.7 mm of ice and 385 N/m^2 of wind.

3. APPLICABLE STANDARDS

Except as stated otherwise, insulators shall comply with the appropriate specification as follows:

Title	ANSI
Test methods for electrical power insulators	C29.1.1976
Wet process porcelain and toughened glass insulators (suspension type)	C29.2-1977
Wet process porcelain insulators (High voltage line - post type)	C29.7-1977
Wet process porcelain insulators (apparatus, post type)	C29.9.1971

4. ELECTRICAL AND MECHANICAL REQUIREMENTS

4.1

Insulators shall meet the electrical and mechanical requirements specified on referenced drawings. Alternatively, they shall conform to suppliers product or equivalent where identified.

4.2

Minimum requirements for the insulators are:

Highest operating voltage (across the insulator)	-	55 kV rms
Minimum impulse withstand voltage	-	350 kV peak
Minimum power frequency withstand voltage (wet)	-	140 kV rms
Minimum total leakage distance	-	1400 mm
Maximum RIV at 55 kV rms and 1000 kHz	-	200 microvolts
Short Circuit Level	-	20000 A

4.3

Insulators shall be clearly and permanently marked with their type designation, manufacturer's name and year of manufacture.

5. INSULATORS

Item 1 - Rod Insulator per Drawing 2-503149 and otherwise as per ANSI* C29.9.1971 TR No. 216.

Item 2 - Rod Insulator per Drawing 2-503150 and otherwise as per ANSI* C29.9-1971 TR No. 216.

Item 3 - Rod Insulator per Drawing 2-503272 and otherwise as per ANSI* C29.9-1971 TR No. 216.

* Where there is conflict between this standard and the Drawing the latter shall govern.

Item 4 - Clevis Type Suspension Insulator Ohio Brass No. 32439 or equivalent, string of five and otherwise as per ANSI C29.2-1977.

Item 5 - Station Post Type Insulator Ohio Brass No. 231006 or equivalent and otherwise as per ANSI C29.9-1971 TR216.

Item 6 - Line Post Type Insulator similar to Ohio Brass No. 42539 or equivalent.

Item 7 - Line Post Type Insulator similar to Ohio Brass No. 43980 or equivalent.

6. TESTS

6.1

Tests shall be conducted on each type of insulator in accordance with its referenced ANSI Standard.

6.2

For the "design tests" the test reports by a certified laboratory will be accepted at the discretion of Chief Engineer. Alternatively, the supplier shall be responsible for carrying out the tests which shall be witnessed by the Chief Engineer or his representative.

6.3

Routine tests shall be conducted by the supplier according to the referenced ANSI Standard.

6.4

In addition to the aforementioned tests the insulators shall be subjected to an ultrasonic test the details of which will be provided with the contract.

7. INFORMATION REQUIRED WITH TENDER

7.1

For each type of insulator quoted the supplier shall complete and submit at time of tender the list of technical characteristics at Appendix A.

8. DELIVERY

Fifty percent of each type of insulator shall be delivered by 31 March 1983 and the remainder by 31 May 1983.

APPENDIX A

1.	Type and Catalogue No.		
2.	Cantilever Strength	Nm	
3.	Tensile Strength	N	
4.	Torsional Strength	Nm	
5.	Compression Strength	N	
6.	Mechanical and Electrical Strength	N	
7.	Mechanical Impact Strength	N	
8.	Power Frequency Withstand Voltage - Dry	kV rms	
9.	Power Frequency Critical Flashover Voltage - Dry	kV rms	
10.	Power Frequency Withstand Voltage - wet	kV rms	
11.	Impulse Withstand Voltage 1.2/50 microsec.	kV peak	
12.	Impulse Critical Flashover Voltage	kV peak	
13.	Power Frequency Puncture Voltage	kV rms	
14.	Radio Influence Voltage at Highest Operating Voltage at 1000 kHz	microvolt	
15.	Description and Colour of Glazing		
16.	Type and Method of Cementing of Caps		
17.	Description (type and grade) of Material used for the Caps		
18.	Provide Dimension Drawing of Insulators		
19.	Attach Available Test Reports		

Steel Tube for Cantilevers Specification

STEEL TUBE FOR CANTILEVERS
SPECIFICATION
FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES LTD.
Montreal, Canada
February 1983

STEEL TUBE FOR CANTILEVERS
SPECIFICATION

1. SCOPE

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line, a route distance of some 130 kms, for 50 kV operation. Sketch 4 attached shows the project location.

This specification covers the design, manufacture, factory testing and delivery of steel tubing which is needed for the fabrication of cantilevers which will support the overhead wires.

2. APPLICABLE STANDARDS

Standard	Title
CSA CAN-G40.21M81	Structural Quality Steels
CSA CAN3-G40.20M81	General Requirements for Rolled or Welded Structural Quality Steel
CSA G164-M1981	Hot Dip Galvanizing of Irregularly-shaped Objects

3. TUBING AND QUANTITY

Tubing is required in random lengths as follows:

Size	Quantity metres	Minimum Length metres
55 mm O.D.	9000	5
42 mm O.D.	2400	5
27 mm O.D.	5500	5

4. MECHANICAL REQUIREMENTS

4.1 MATERIAL

Structural quality steel in accordance with CSA Standard CAN3-G40.21M81 350 WT Class H.

4.2 MANUFACTURE

Circular cross section, electrical longitudinal fuse welding. Outer weld swelling shall be removed. Small inner weld swelling acceptable. Tubes shall be cut perpendicular to the tube axle and free of sharp edges (buss removal). Tubes shall be straight to visual inspection.

4.3 HEAT TREATMENT

Normalizing in accordance with CSA Standard G40.20-M81.

4.4 DIMENSIONS

4.4.1 55 mm tube: O.D. - 55 mm
wall thickness - 4 mm.

4.4.2 42 mm tube: O.D. - 42 mm
wall thickness - 4 mm.

4.4.3 27 mm tube: O.D. - 26.9 mm
wall thickness - 3.6 mm.

4.4.4 Tolerances

O.D.: ± 0.4 mm
wall thickness: ± 10%

4.5 SURFACE TREATMENT

Tubes shall be hot dip galvanized in accordance with CSA Standard G164-M1981.

5. TESTS

Sampling and testing shall be done in accordance with C.S.A. Standard G40.20M81.

5.1

Certification shall be furnished in accordance with Clause 16.

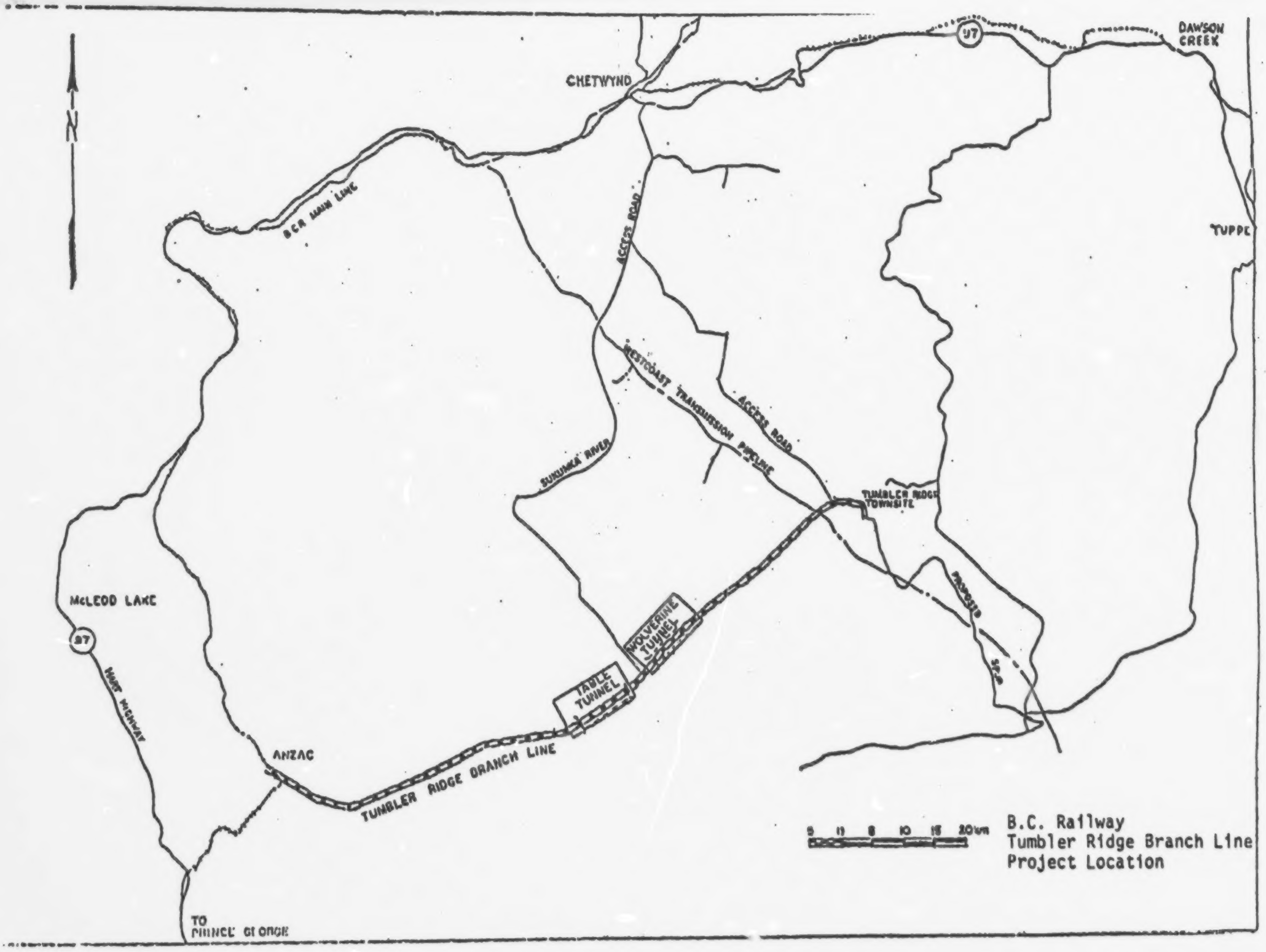
5.2

Impact test shall be per Charpy V-Notch method Category 4.

6. PACKAGING

Tubes shall be delivered in bundles of approximately one ton bound firmly together with steel strapping. Bundles shall be comprised of one diameter tubing only and shall be marked with a weather resistant tag detailing size (diameter) and number of tubes.

Complete delivery of tubes is required by February 22, 1983.


N
CHETWYND
97
DAWSON CREEK
TUPPE
BCR MAIN LINE
ACCESS ROAD
WESTCOAST TRANSMISSION PIPELINE
ACCESS ROAD
SUKUNKA RIVER
TUMBLER RIDGE TOWNSITE
PROPOSED
SCP
WOLVERINE TUNNEL
TABLE TUNNEL
TUMBLER RIDGE BRANCH LINE
ANZAC
McLEOD LAKE
97
HART HIGHWAY
TO PRINCE GEORGE
0 5 10 15 20 km

B.C. Railway
Tumbler Ridge Branch Line
Project Location

Bolt Specification

BOLT SPECIFICATION
FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES LTD.
Montreal, Quebec
February, 1983

BOLT SPECIFICATION

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line, a route distance of some 130 kilometres, for 50 kV, 60 Hz operation.

Sketch A attached shows the project location.

2. SCOPE

This specification covers the supply and delivery of various standard bolts and nuts as well as the fabrication supply and delivery of some special ones.

3. APPLICABLE STANDARDS AND DRAWINGS

ASTM A325-74	High Strength bolts for structural steel joints including suitable nuts and plain hardened washers.
ASTM A-153	Zinc Coating (hot dip) on iron and steel hardware.
Drw No. 3032-6-4001	U-Bolt Assembly Component No. 875
Drw No. 4-503109	Threaded Hook Fastener
Drw No. 4-503110	Threaded Hook Fastener
Drw No. 4-503095	Wax Nuts

4. COMPONENTS

4.1 Unless otherwise specified, all bolts, nuts, screws and washers comply with ASTM A325-74 and ASTM 153. Items required are as follows:

		Quantity
4.2	Hook Screw per drawing 4-503109	
	Part No. 04-14-002-6	11,000
	Part No. 04-14-001-8	11,000
	Part No. 04-14-003-4	2,900
4.3	Hook Screw per drawing 4-503110	
	Part No. 04-14-012-5	250
4.4	BOLTS	
4.4.1	(Weight Tensioning & Fixed Anchor requirements)	
	3/4" UNC x 7" c/w nut & 2-1/2" O.D. washer	2,250
	3/4" UNC x 3-1/4" c/w nut & 2-1/2" O.D. washer	60
	3/4" UNC x 12" c/w nut & 2-1/2" O.D. washer	200
4.4.2	(Single, Twin Arm & Bridge Cantilever requirements)	
	3/4" UNC x 5-1/2" c/w nut & 2-1/2" O.D. washer	650
4.4.3	(Earth Wire Suspension with extension requirement)	
	3/4" UNC x 1-3/4" c/w nut & 2-1/2"O.D. washer	900
4.4.4	(Bracket attachment for auto-tension tunnel registration support)	
	1/2" UNC x 1-1/2" c/w nut & 2-1/4" O.D. washer	300
4.4.5	(Pole Extension)	
	M20 x 45 c/w nut & 20 x 3 x 63 washer	300

4.4.6 (Portal Structures)

3/4" UNC x 8" c/w nut & 2-1/2" O.D. washer	300
M20 x 50 c/w wax nut per drawing 4-503095 and two washers 21 x 3 x 36	8,500

4.4.7 (Tunnel Hardware)

1/2" UNC x 2" c/w nut & galvanized lockwasher	4,100
1/2" UNC x 6" c/w nut & galvanized lockwasher	1,300
U-Bolt Assembly Component no. 875 per drawing 3032-6-4001	375
Hex nut with lockwasher for 1" diameter bolt both per ASTM A-36 and ASTM A-153	800
Bolt 1" x 2-1/2" c/w nut & galvanized lockwasher	40
Anchor bolt 3/4" x 2'0" Stelco Class 1 350 MPa galvanized per ASTM A-153	9
Anchor bolt 1/2" x 2'0" Stelco Class 1 350 MPa galvanized per ASTM A-153	520
Grounding Split Connector Burndy CABELOK CRIMPIT YC26C26	50
Plate, Joslyn No. 6016	9

5. ACCEPTANCE

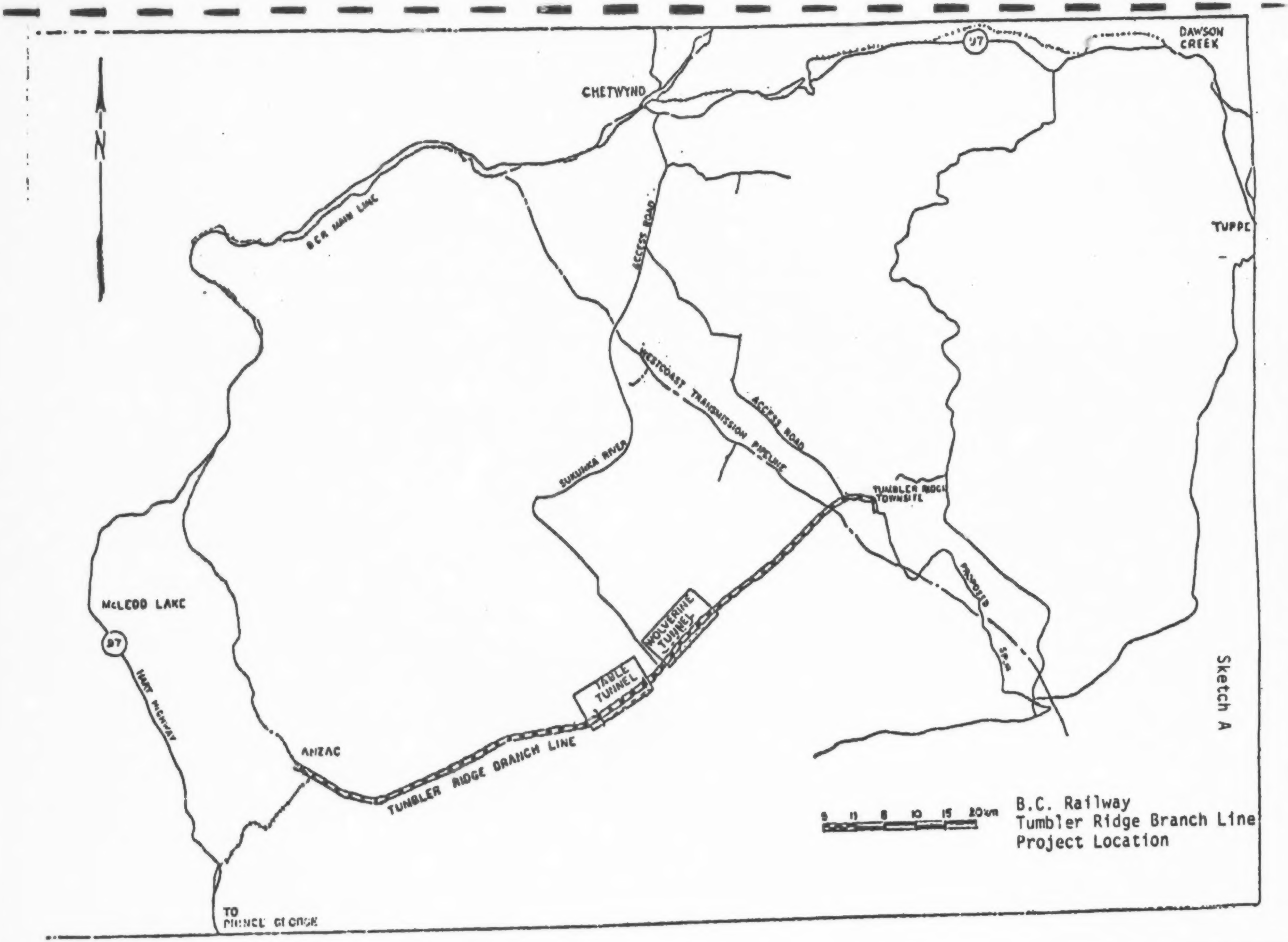
5.1 The supplier shall demonstrate compliance to this specification and referenced standards to the Engineer or his designated representative.

6. SHIPPING AND HANDLING

6.1 Items shall be packaged in reasonable quantities for ease of handling. Packages shall be marked with durable and weather resistant markings which clearly identify their contents and quantities.

Bidders shall state proposed quantities and weight per package when quoting.

6.2 Delivery to the British Columbia Railway location shall begin as soon as possible and be completed by 27 July 1983. Bidders shall state their proposed delivery dates when quoting.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PROPOSED SPUR
WOLVERINE TUNNEL
TABLE TUNNEL
TUMBLER RIDGE BRANCH LINE
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McLEOD LAKE
97
HART HIGHWAY
TO PRINCE GEORGE
5 11 8 10 15 20km

Sketch A

B.C. Railway
Tumbler Ridge Branch Line
Project Location

Miscellaneous Hardware Specification

MISCELLANEOUS HARDWARE SPECIFICATION
FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES LTD.
MONTREAL, QUEBEC
FEBRUARY, 1983

MISCELLANEOUS HARDWARE SPECIFICATION

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line, a route distance of some 130 kilometres, for 50 kV60Hz operation. Sketch A attached, shows the project location.

2. SCOPE

This specification covers the supply and delivery of miscellaneous, standard, off the shelf hardware such as guy rods, anchors, guying dead ends, exothermic connectors for connecting earth return wire to rails, clamps, etc.

3. APPLICABLE STANDARDS AND DRAWINGS

Standards and drawings referred to in this specification are:

ASTM B47-64	Copper trolley wire
ASTM A-47	Malleable iron castings
ASTM A-153	Zinc coating (hot dip) on iron and steel hardware
ASTM A-711	Carbon and alloy steel blooms, billets, and slabs for forging
Drw No. 3-504148	Spring steel clip

4. COMPONENTS

Bidders may quote upon the supply of any or all of the following items. Prices shall be per item.

4.1 GUYING HARDWARE

Slacan plate anchor No. 62401 (or equivalent)	850

4.11	THREE-BOLT WIRE CLAMP	
	per ASTM A-36 galvanized to ASTM A-153 Chance No. 6460 (or equivalent)	10
4.12	STRAIN CLAMP WITH EYE, MALLEABLE IRON GALVANIZED	
	per ASTM A-153 O.B. No. 10572 (or equivalent)	20
4.13	CLAMP	
	70mm^2 HD Cu strand to 3/0 133 strand flexible Cu Pfisterer No. 302-776-909 (or equivalent)	330
4.14	WEDGE-GRIP, MALLEABLE IRON GALVANIZED	
	to ASTM A-153 O.B. No. 12634 (or equivalent)	35
4.15	ANCHOR SHACKLE, FORGED STEEL	
	per ASTM A-711, galvanized per ASTM A-153 O.B. No. 79608 (or equivalent)	65

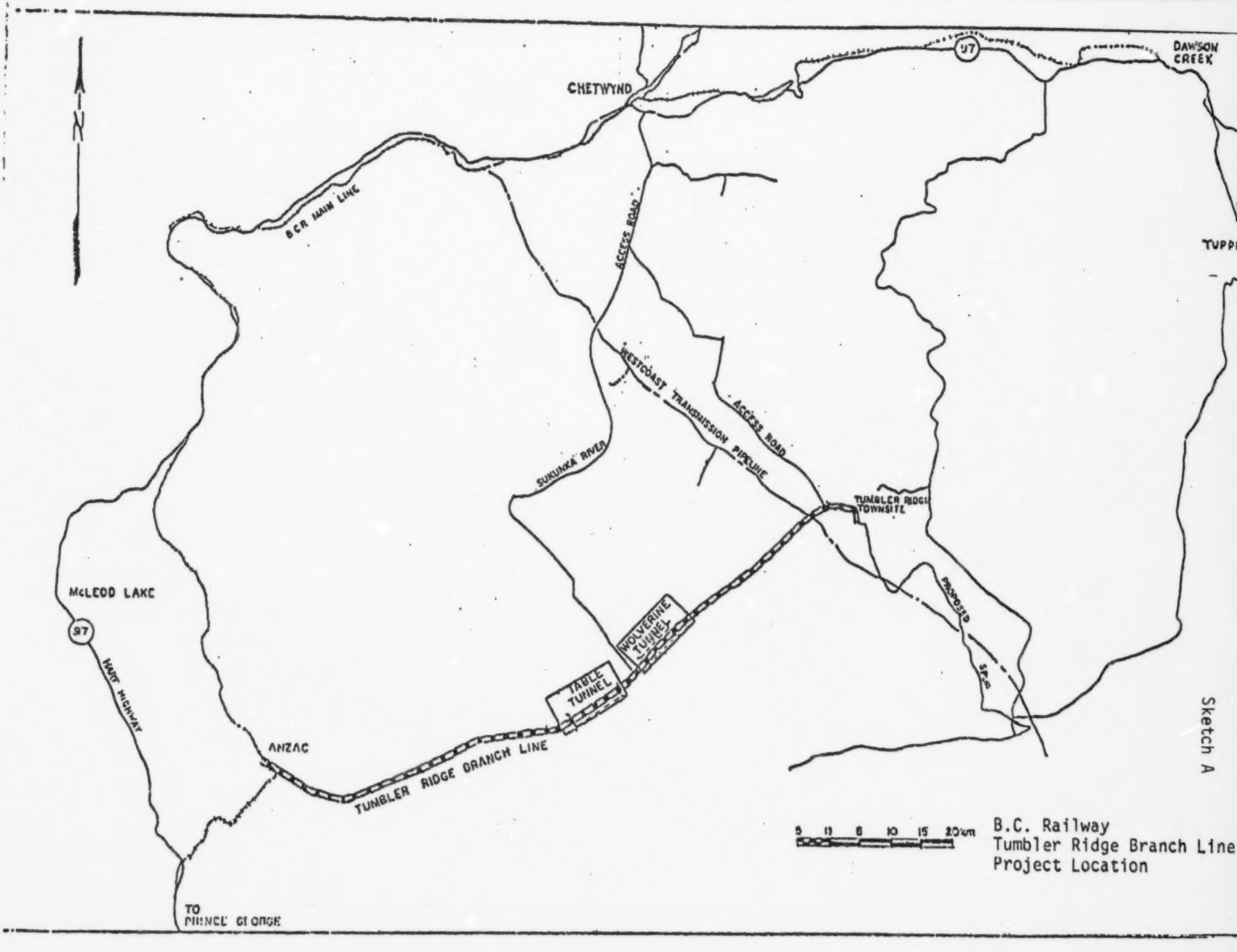
5. ACCEPTANCE

5.1 The supplier shall demonstrate compliance to this specification and referenced standards to the Engineer or his designated representative.

6. SHIPPING AND HANDLING

6.1 Items shall be packaged in reasonable quantities for ease of handling. Packages shall be marked with durable and weather resistant markings to show clearly their contents and quantities. (Bidders shall state proposed quantities per package when quoting).

6.2 Delivery to the British Columbia Railway location shall begin as soon as possible and be completed by
27 July 83. Item 4.1 Guying Hardware is required as soon after 10 May 83 as possible. Bidders shall state proposed delivery schedules.



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WOLVERINE TUNNEL
TUMBLER RIDGE BRANCH LINE
TO PRINCE GEORGE
5 11 6 10 15 20km

Sketch A

B.C. Railway
Tumbler Ridge Branch Line
Project Location

Fabricated Tunnel Hardware Specification

FABRICATED TUNNEL HARDWARE
FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES LTD.
MONTREAL, QUEBEC
FEBRUARY, 1983

Fabricated Tunnel Hardware Specification

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line, a route distance of some 130 kilometers, for 50 kV 60 Hz operations. Sketch 'A' attached, shows the project location.

2. SCOPE

This specification covers the fabrication, supply and delivery of various steel members required to construct the tunnel supports of the overhead contact system (OCS).

3. DRAWINGS AND STANDARDS

The following drawings and standards form part of this specification.

Drawing No.	Title
3032-6-4002	Circular plate component no. 871
3032-6-4003	Stand-off steel pipe component no. 872
3032-6-4002	Messenger clamp spacer comopnent no. 877
3032-6-4001	Registration support tee (curve) component no. 880
3032-6-4001	Retistration support tee (tangent) component no. 879
3032-6-4003	Insulator support channel (cavernous) component no. 881
3032-6-4001	Insular support channel (cavernous) component no. 882
3032-6-4002	Anchor bracket component no. 888
3032-6-4003	Taper washer component no. 895
3032-6-4003	Strain strap component no. 896
3032-6-4002	Square plate component no. 998
3-503782	Contact knuckle
3-503658	Bracket for pulley

Standard No.	Title
ASTM A-36	Structural steel
ASTM A-153	Zinc coating (hot dip) on iron and steel hardware
CSA G40.21M	Structural quality steels
CSAG164	Hot dip galvanizing

4. COMPONENTS

4.1 Bidders are requested to quote upon the fabrication, supply and delivery of the following structural components. Prices shall be stated per unit.

4.2 Steel shall conform to the requirements of ASTM A-36 and galvanizing to ASTM A-153.

4.3 Components and their quantities are as follows:

Circular plate per drawing 3032-6-4002	Qty 750
Stand-off steel pipe per drawing 3032-6-4003 in standard lengths (18-23 ft)	Qty 425
Messenger clamp spacer per drawing 3032-6-4002	Qty 325
Registration support Tee (curve) per drawing 3032-6-4001	Qty 10
Registration support Tee (tangent) per drawing 3032-6-4001	Qty 340
Insulator support channel (cavernous) per drawing 3032-6-4003	Qty 30

Insulator Support Channel per drawing 3032-6-4001	Qty	375
Anchor bracket per drawing 3032-6-4002	Qty	115
Taper washer per drawing 3032-6-4003	Qty	675
Strain strap per drawing 3032-6-4003	Qty	50
Square plate per drawing 3032-6-4002	Qty	750
Contact knuckle per drawing 3-503782	Qty	20
Bracket for pulley per drawing 3-503658	Qty	40

5. ACCEPTANCE

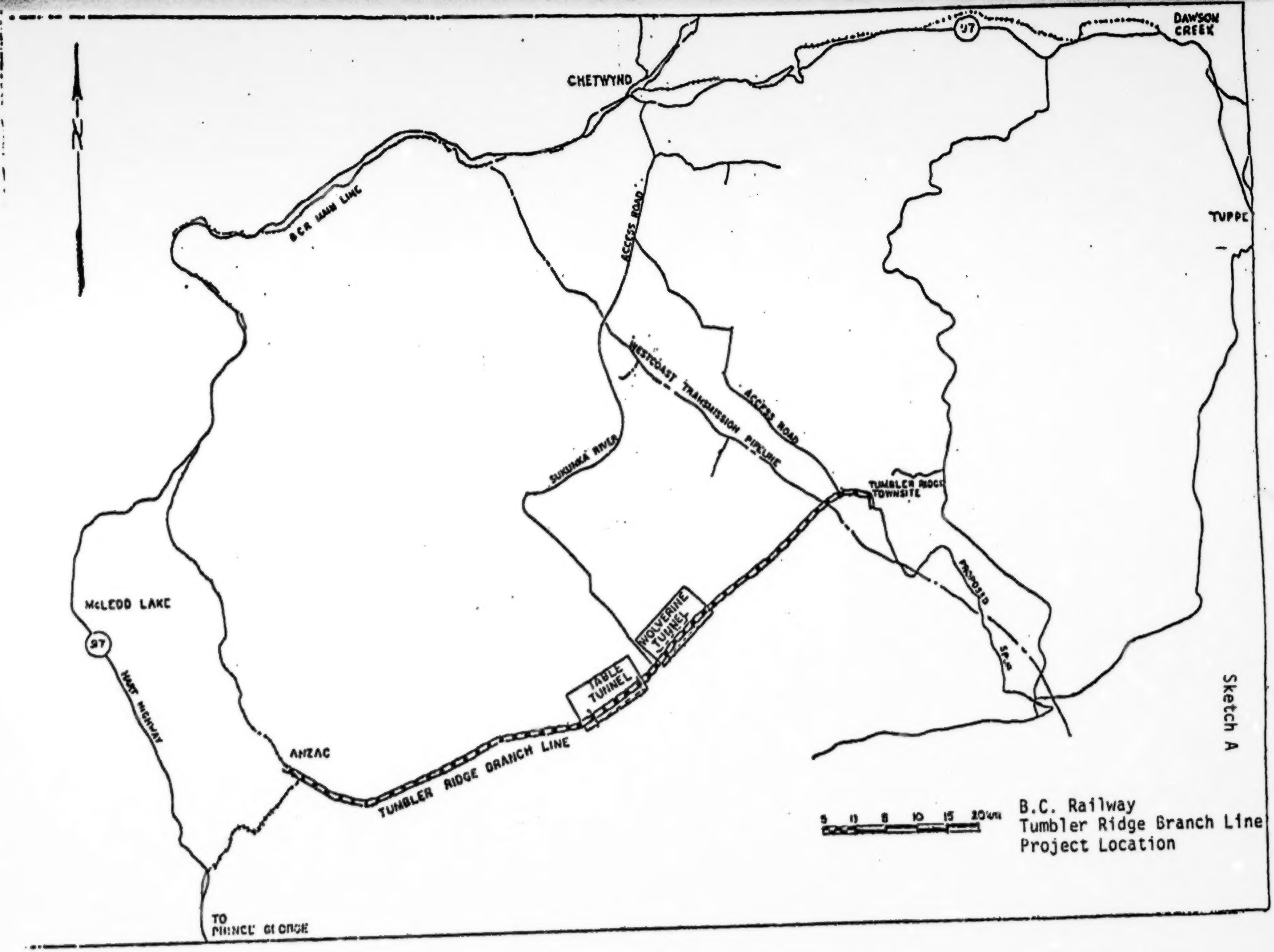
5.1 The supplier shall demonstrate compliance to this specification and other referenced standards to the Engineer or his designated representative.

6. SHIPPING AND HANDLING

6.1 Items shall be packaged in reasonable quantities for ease of handling. Bidders shall state quantities and weight per package. Packages are to be marked with durable and weather resistant markings to show clearly the contents and quantities.

6.2 Delivery to the British Columbia Railway location shall begin as soon as possible after 10 May 83 and shall be completed by 27 July 83.

Bidders shall state proposed delivery schedules.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McLEOD LAKE
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HART HIGHWAY
TO PRINCE GEORGE
5 0 5 10 15 20km

Sketch A

B.C. Railway
Tumbler Ridge Branch Line
Project Location

Wire Specification

WIRE SPECIFICATION FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES
MONTREAL, QUEBEC
REVISION No. 1 - JANUARY, 1983

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line, a route distance of some 130 kilometres, for 50 kV, 60 Hz operation. Sketch A attached shows the project location.

2. SCOPE

2.1 This specification covers the manufacture, supply and delivery of wire, cable, joints and dead ends for the overhead contact system, feeder and return circuits, ground wire, guy strands, dropper-wires and jumpers.

3. APPLICATION STANDARDS

Where stated, the wires shall conform to the requirements of the appropriate one of the following standards:

Standard	Title
ASTM B47-64 (reapproved 1969)	Copper trolley Wire (grooved)
ASTM B8-71	Concentric Lay Stranded Copper Conductors
CSA C49.1 - 1975	Aluminum Conductors Steel Re-inforced
CSA CAN 3-G12-1978M	Steel Wire Strand
ASTM B173-71	Rope Lay Stranded Copper Conductors having Concentric Stranded Members, for Electrical Conductors.
ASTM B-1	Hard Drawn Copper Conductors

4. ITEMS

Bidders are invited to quote on the supply of any or all of the following wire and material in the quantities shown.

4.1 107 mm^2 Hard-Drawn Copper Trolley Wire (grooved) per ASTM B47-64 (See Figure 1 attached)

Wire Length/Reel (continuous)	Number of Reels (1)
2300 m	5
2200 m	
1800 m	1
1700 m	1
1500 m	56 + 1
1400 m	31 + 1
1300 m	20 + 1
1200 m	14 + 1
1100 m	9
1000 m	9

4.2 70 mm^2 (19 Strand) Hard-Drawn Copper Class B per ASTM B8

Overall Diameter - 10.85 mm
Strand Diameter - 2.17 mm
Minimum Breaking Strength - 28,469 N.

(1) Wire shall be reeled such that when paid out under 7000 N tension it does not cut into underlying layers.

Minimum diameter of drum shall be such that the contact wire shall straighten when unwound under 7000 N tension.

Contact wire shall be reeled with small bead uppermost.

Wire Length/Reel (continuous)	Number of Reels
2200 m	15
2100 m	9
2000 m	6
1500 m	62 + 1
1400 m	37 + 1
1300 m	19 + 1
1200 m	13 + 1
1100 m	15 + 1
1000 m	17 + 1

4.3 4/0 ACSR Penguin per CSA C49.1-1975

Wire Length/Reel	Number of Reels
1300 m	183

4.4 Goose ACSR (322mm^2) per CSA C49.1-1975

Wire Length/Reel	Number of Reels
1590 m	4

4.5 3/8" Grade 180 Steel Wire Strand per CAN3-G12-1978 M

Wire Length/Reel	Number of Reels
1000 m approx.	43

		Quantity
4.6	Rope Lay Concentric Stranded Flexible Soft-Drawn Copper Conductor per ASTM-B173	
	3/0 133 (G) Strand each wire 0.0355 in dia., 0.533 in overall diameter	4000 meters
	No. 3 AWG 133 (H) Strand each wire 0.0199 in dia., 0.299 in overall diameter.	5000 meters
	To be delivered approximately 500 m/reel.	
4.7	Concentric Lay Stranded Medium Hard-Drawn Copper Conductor Class B per ASTM-B8	
	AWG 1/0 19 (B)	10,000 meters
4.8	Solid Hard-Drawn Copper Conductor per ASTM B-1	
	Diameter 5 mm	31,000 meters
4.9	Unisplice Full Tension Splice for 4/0 ACSR (Penguin)	
	Burndy Catalogue No. YD S28RL (or equivalent)	250 pieces
4.10	Dead end clamp	
	Burndy Catalogue No. CUW30A-E (or equivalent)	100 pieces 100 pieces

4.11	Tubular Compression Joint Assemblies for Goose ACSR	
	Alcan Catalogue No. TJA-132 (or equivalent)	25 pieces
4.12	Hysplice Full Tension splice for 70 mm^2 19 Strand HD Copper Conductor O.D.O. 427 inches	
	Burndy Catalogue YDS26* (or equivalent)	300 pieces
4.13	Connector for Overhead Tap	
	Burndy Cabelok Crimpit Catalogue No. YPC28U28	800 pieces
4.14	Earth Wire Support	
	Slacan Saddle Clamp No. 22361	2200
	Slacan 1/2" Shackle No. 6801	2200
4.15	Copper Terminal	
	Burndy HYLUG No. YAL25T12	1600
	Burndy HYLUG No. YAL26T12± (or equivalent)	800
4.16	Durium Hardware	
	Bolt 1/2" X 1 1/2" Burndy HEB50 X 150	800
	Hex Nut 1/2" X 1 1/2" Burndy HEN50	800
	Flatwasher 1/2" X 1 1/2" Burndy FW50	800
	Split Lockwasher 1/2" X 1 1/2" Burndy SW50	800

* Supplier to confirm adequacy for use on 70mm^2 Strand.

5. ACCEPTANCE

5.1 The supplier shall demonstrate compliance with the requirements of this specification and other referenced standards to the Engineer or his Designated Representative.

6. SHIPPING AND HANDLING

6.1 Wire shall be shipped in the lengths specified on standard reels. Supplier shall state the capacities and weights when tendering.

6.2 Reels shall be clearly marked to show the type of wire and its length.

6.3 Compression joints, dead end assemblies and connectors shall be packaged separately in reasonable quantities in packages that can be handled manually. They shall be marked to clearly show their contents and quantities.

6.4 All markings shall be durable and weather resistant.

6.5 Delivery to the British Columbia Railway location will be specified in the purchase order. It shall begin as soon as possible after February 22nd, 1983 and be completed by May 10th, 1983.

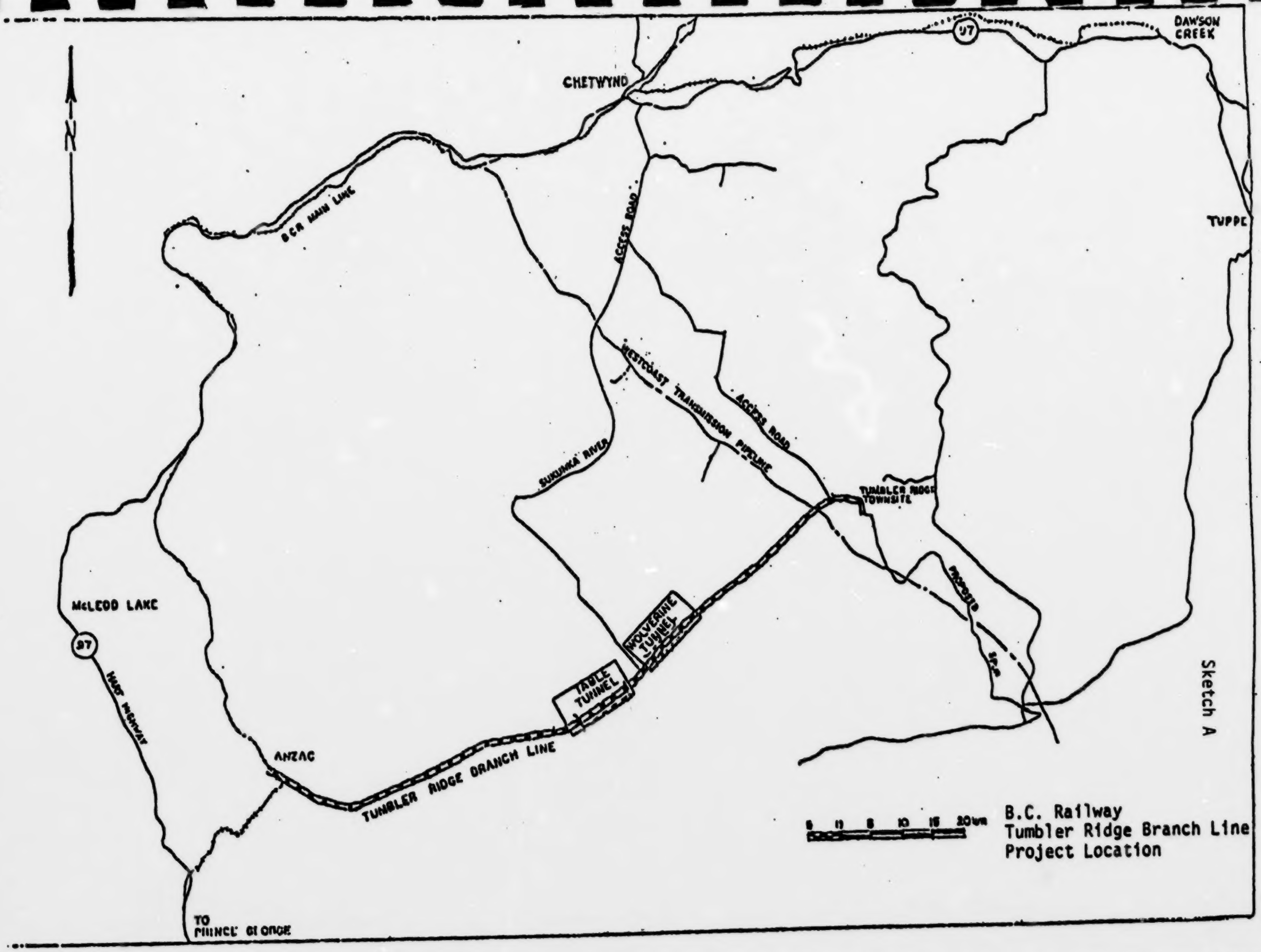
The tenders shall state the phased delivery quantities proposed between these dates.

7. INFORMATION REQUIRED WITH TENDER

The bidders shall submit the following information when tendering.

7.1 State if the tender complies in every respect (yes or no) with this specification.

7.2 Attach description and location of manufacturing facilities.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TUMBLER RIDGE TOWNSITE
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TABLE TUNNEL
TUMBLER RIDGE BRANCH LINE
McLEOD LAKE
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HART HIGHWAY
ANZAC
TO PRINCE GEORGE
0 5 10 15 20km

Sketch A

B.C. Railway
Tumbler Ridge Branch Line
Project Location

Section Insulators and Neutral Sections Specification

SPECIFICATION FOR SECTION INSULATORS AND NEUTRAL SECTIONS

The following is a direct transcription of the Specification for Section Insulators and Neutral Sections as transmitted to British Columbia Railway on February 1, 1983.

1.0 GENERAL

Maximum Operating Voltage:	57.5 kV rms
Frequency:	60 Hz
Wet Power Frequency Test Voltage - 10 sec.	140 kV rms
Minimum Creepage Distance:	1400 mm
Lightning Impulse Withstand Voltage:	350 kV peak
Contact Wire:	4/0 (107 mm2) H.D. Cu per ASTM B 47
- Minimum Breaking Strength	34.52 kN
- Maximum Tension	10 kN
Messenger Wire:	70 mm^2 19 strand H.D. Cu
- Minimum Breaking Strength	29 kN
- Maximum Tension	10 kN
Pantograph:	Double Contact Strip
- Total Width	2000 mm
- Carbon Strip	1200 mm
Maximum Passover Speed:	65 km/h

The insulators are passed over in both directions. They will be erected in an area of harsh winter climate. Coal will be transported by the Railway.

2.0 SECTION INSULATOR ASSEMBLY

The section insulators are passed over without interruption of current. The tenderer shall provide full details as to dimensions, weight, mechanical and electrical characteristics, and installation instructions with his proposal.

3.0 NEUTRAL SECTION ASSEMBLY

The insulator is passed with interruption of current. The tenderer shall provide full details as to dimensions, weight, mechanical and electrical characteristics, and installation instructions with his proposal.

4.0 MESSENGER INSULATOR

Tenderer shall quote the messenger insulator separate from the section insulators and shall provide details as to dimensions, weight, mechanical and electrical characteristics, and installation instructions with his proposal.

5.0 QUANTITIES

Section Insulator Assemblies	-	25
Neutral Section Assemblies	-	2

6.0 SHIPPING AND HANDLING

Insulators shall be packaged to permit handling manually and protected from damage.

Delivery shall be complete by June 30, 1983.

Steel Wire Rope Specification

SPECIFICATION FOR
STEEL WIRE ROPE
FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIGE BRANCH LINE
50 kV ELECTRIFICATION

CANADIAN PACIFIC CONSULTING SERVICES LTD.
MONTREAL, QUEBEC
January 1983

SPECIFICATION FOR STAINLESS STEEL WIRE ROPE

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line for 50 kV 60 Hz operation. The project extends for some 130 route kilometres located as shown on sketch A, attached.

2. SCOPE

This specification covers the design, manufacture and supply of stainless steel wire rope required for the automatic weight-tensioning equipment.

2.1 A typical installation is shown in Sketch No. 12 attached. The wire rope is between the weights of 24, around the pulleys and terminated at 32.

2.2 It is essential that the wire rope be non-rotating and not cause rotation of the weights as they move up or down.

3. STANDARDS

The following standard forms part of this specification:

AISI 316 - Stainless Steel Wire Rope

4. MECHANICAL REQUIREMENTS

The stainless steel wire rope shall conform to mechanical and material requirements as specified in the following clauses.

4.1 MATERIAL

Material shall be in accordance with AISI 316 Stainless Steel Wire Rope.

4.2 CONSTRUCTION

Construction shall be 12 x 6 + 3 x 24 = 144 wires non-rotating, i.e. 12 outer strands around 3 inner strands, around a fibrous core. The 3 inner strands each comprise 15 wires around 9 wires around a fibrous core.

The 12 outer strands each comprise 6 wires around a fibrous core.

The fill factor, F is 51%.

Figure 1 shows the configuration.

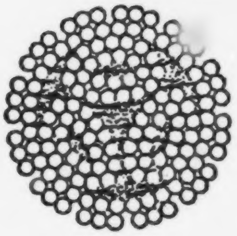


Figure 1.

4.3 DIMENSIONS AND WEIGHT

Nominal diameter:	10 mm - 5% - 1%
Metallic Area:	39.9 mm^2
Approximate Weight:	38 kg/100 m

4.4 STRENGTH

Wire rope minimum breaking load - 46.9 kN.

4.5 ALTERNATIVES

Provided that size, strength and flexibility is equivalent, alternative constructions of non-rotating stainless steel wire rope will be considered.

5. QUANTITY

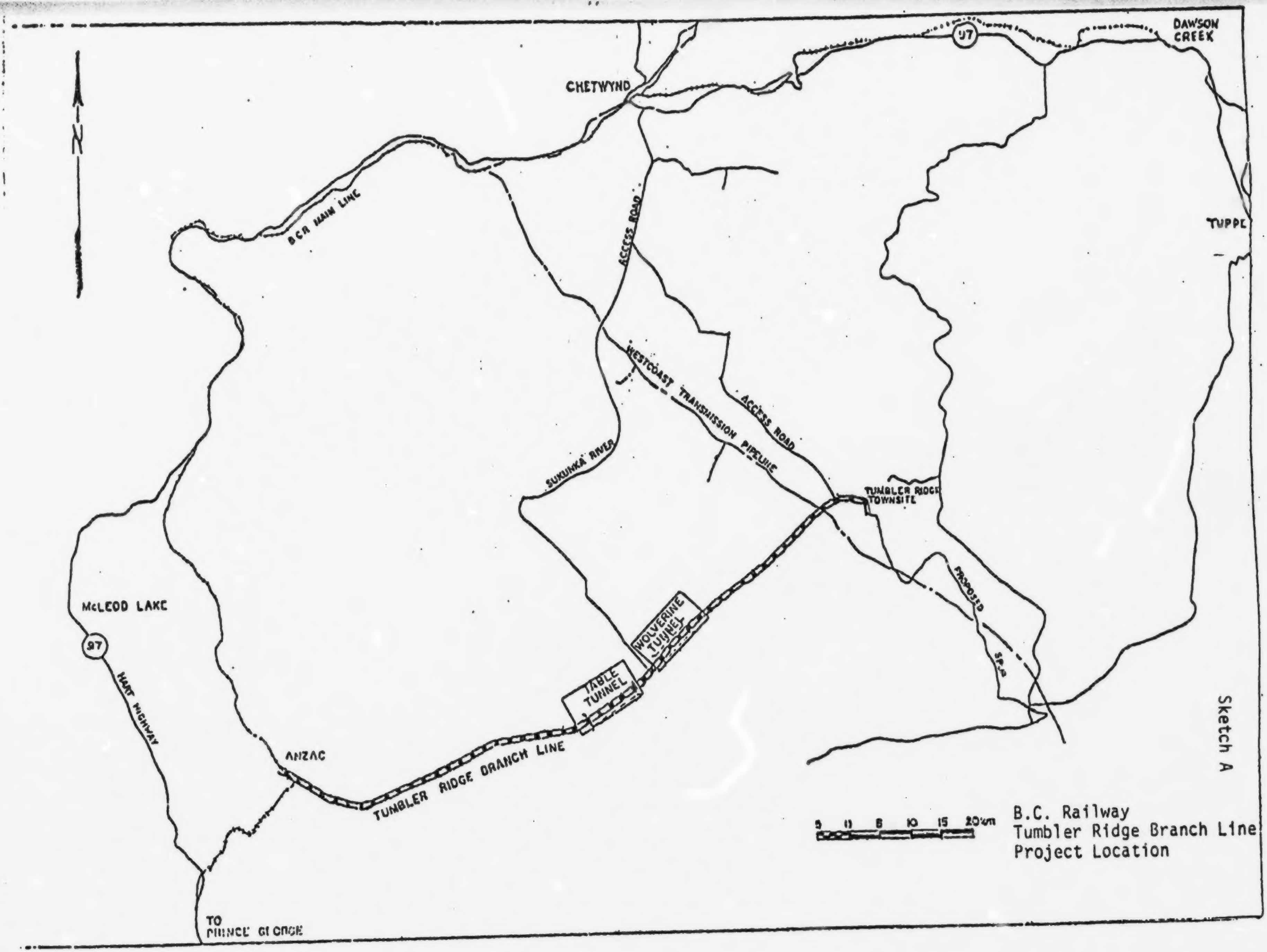
7.2 metre lengths	300 pieces

6. PACKAGING

The wire rope shall be packaged in 7.2 m lengths with the ends tapered and fused to prvent unravelling. Each length shall be coiled and lashed to prevent unwinding.

7. DELIVERY

Delivery to the British Columbia Railway location will be specified in the purchase order and shall begin as soon as possible after February 28, 1983 and be completed by April 16, 1983.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HART HIGHWAY
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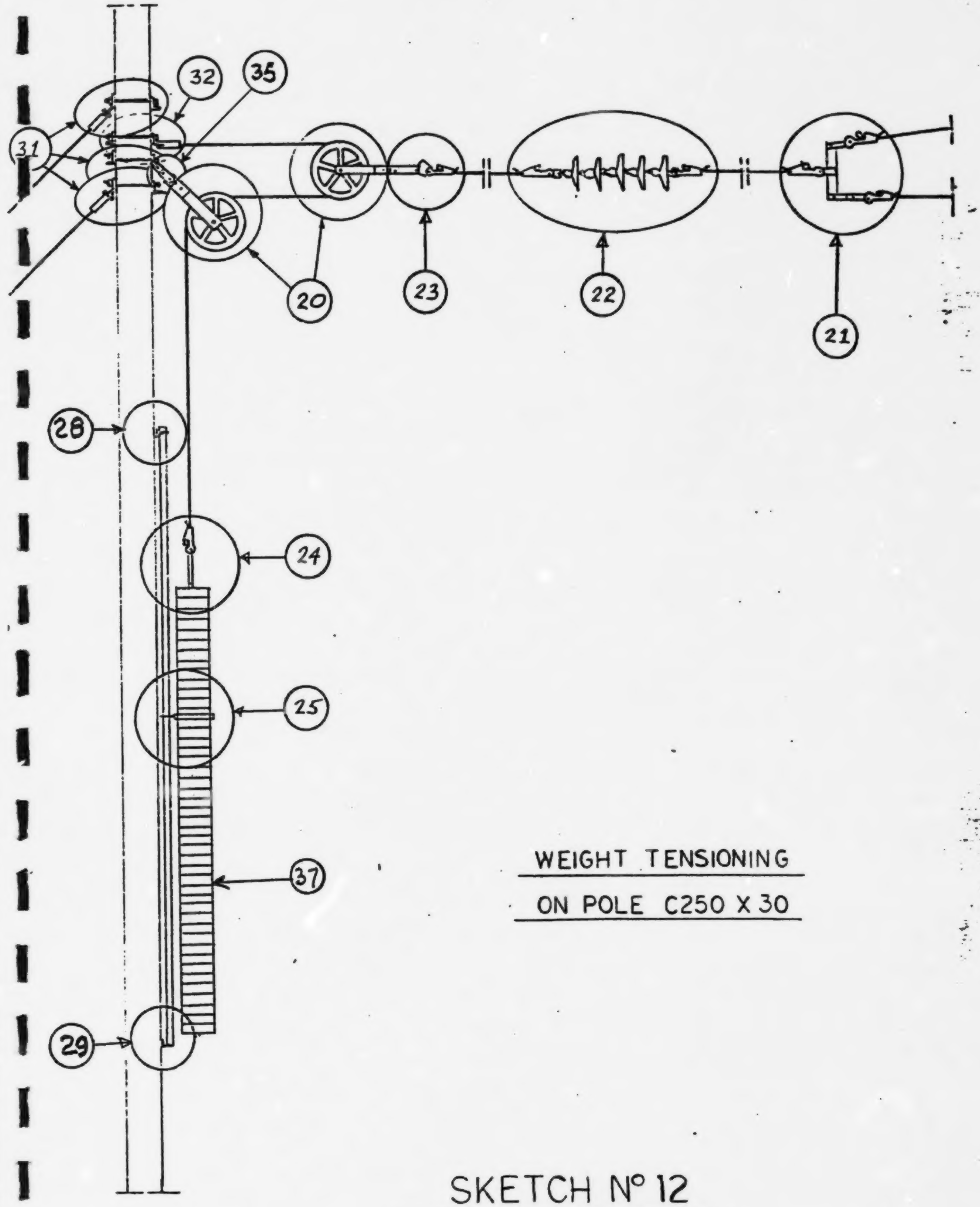
Sketch A

B.C. Railway
Tumbler Ridge Branch Line
Project Location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WEIGHT TENSIONING
ON POLE C250 X 30

SKETCH N° 12

Dropper Specification

BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE ELECTRIFICATION
DROPPER SPECIFICATION

Canadian Pacific Consulting Services Ltd.
Montreal, Quebec
April 1983

DROPPER SPECIFICATION

1. GENERAL

The British Columbia Railway is electrifying its Tumbler Ridge Branch Line. Thsi is a new railroad being constructed between Anzac, some 130 kilometres north of Prince George, to the Tumbler Ridge Township, a new coal mining community about 120 kilometres further north east.

The railroad is intended to haul unit coal trains from the North East Development project mines. Sketch A attached shows the project location.

2. SCOPE

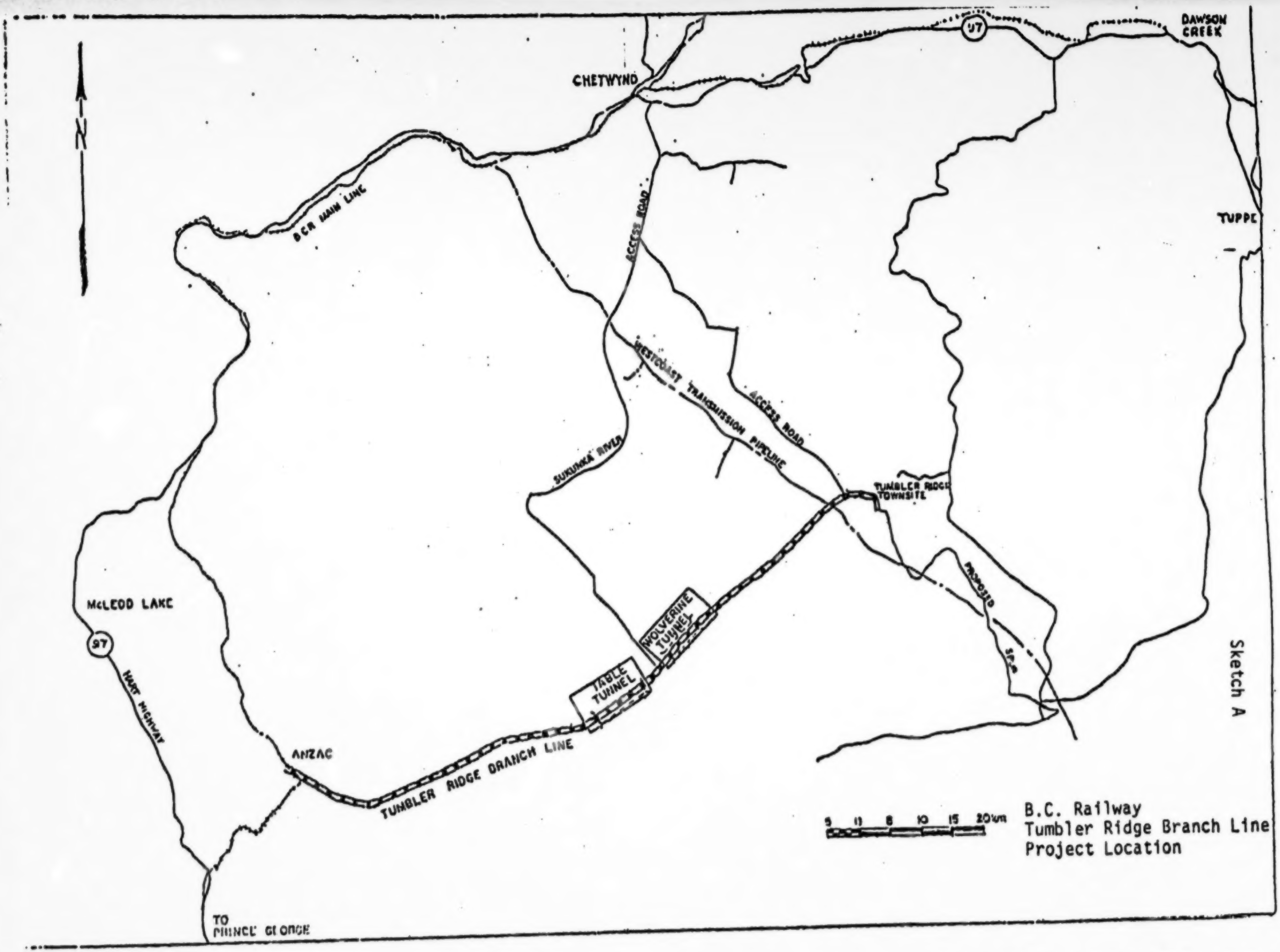
This specification covers the fabrication of droppers (also called hangers) which will suspend an electric contact wire from a messenger wire. The messenger and contact wire form part of the overhead conductor system which provides traction power to the pantograph of electric locomotives.

All dropper material will be provided by B.C. Railway.

3. DRAWINGS

The following drawings form part of this specification.

Drawing	Title
3032-4-4001	Standard Catenary Span Set SM-1
3032-4-4002	Standard Catenary Span Set SM-2
4-503278	Eye for Dropper Part No. 04 24 221-0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5 11 8 10 15 20km

Sketch A

B.C. Railway
Tumbler Ridge Branch Line
Project Location

4. DETAILED REQUIREMENTS

4.1 The supplier shall fabricate droppers as shown on drawing 4-503274 inclusive of thimble eyes, but excluding the clamps which go through these eyes; in the lengths and quantities shown on the attached computer print out.

4.2 The initial order is for approximately 80% of the total as shown separately under "order". Procurement of the remaining 20% is designated as "on hold".

This "on hold" quantity which will not decrease in total numbers, may have changes in quantities of some of the lengths. The total quantity may increase.

The "on hold" procurement will be made upon completion of the field confirmation of requirements. This is forecast for early July, 1983.

4.3 The supplier should note that the dropper length "L" is the formed length measured from the end of eye to the end of eye.

The length of 5 mm hard drawn copper wire, from which the dropper is fabricated will exceed "L" by the amount required to encircle the eyes and the wraps below the eyes.

4.4 Each dropper shall be marked with a durable plastic tape designating its length "L" in mms.

5. MATERIAL

5.1 The following material will be provided to the successful bidder for the fabrication of droppers.

5 mm diameter hard drawn copper conductor	- 13,000 metres
Eye for dropper	- 32,000

5.2 Upon completion of the work, cable reels and any unused material shall be returned to B.C. Railway.

6. PACKAGING AND DELIVERY

6.1 Droppers shall be packaged in bundles of length "L" in quantities no greater than fifty.

6.2 Droppers shall be packaged so as to be protected from damage while handling.

6.3 Packages shall be clearly marked with a durable marking designating items and quantity.

6.4 Delivery to the British Columbia Railway site named in the purchase order shall begin as soon as possible after receipt of order and be completed by July 31, 1983.

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DATE 19 APR 83  10:24:37     REPORT GENERATION     MIKE

                                                          PAGE    -1-
 C82079   BCR TUMBLER RIDGE BRANCH LINE ELECTRIFICATION   DROPPER REQUIREMENT

DROPPER        TOTAL

LENGTH MM  QUANTITY     ORDER   ON HOLD

========.=.==========.=========.========.

     165          1         0        1

     175          2         0        2

     195         14        11        3

     205          3         0        3

     210         24        19        5

     220          2         0        2

     230          3         0        3

     235         10         8        2

     245          3         0        3

     250          2         0        2

     275          2         0        2

     280          7         0        7

     300          4         0        4

     305         14        11        3

     310        562       450      112

     315          2         0        2

     340          3         0        3

     355          3         0        3

     375         12        10        2

     380          5         0        5

     390          2         0        2

     420         12        10        2

     425       1698      1358      340
```

DROPPER LENGTH MM	TOTAL QUANTITY	ORDER	ON HOLD
440	4	0	4
445	2	0	2
450	6	0	6
455	1	0	1
460	2	0	2
480	32	26	6
495	1690	1352	338
515	152	122	30
520	6	0	6
535	66	53	13
540	99	79	20
545	32	26	6
555	4	0	4
560	66	53	13
565	7	0	7
580	117	94	23
585	152	122	30
590	1	0	1
600	53	42	11
605	32	26	6
615	5	0	5
630	61	49	12
635	44	35	9
640	53	42	11
645	2	0	2

DROPPER LENGTH MM	TOTAL QUANTITY	ORDER	ON HOLD
650	1754	1403	351
655	128	102	26
660	1	0	1
665	26	21	5
670	12	10	2
675	39	31	8
680	1	0	1
685	148	118	30
695	5	0	5
700	6	0	6
705	117	94	23
710	152	122	30
715	6	0	6
720	10	8	2
730	15	12	3
740	65	52	13
745	11	9	2
750	45	36	9
755	54	43	11
760	3	0	3
765	116	93	23
770	12	10	2
780	15	12	3
785	148	118	30
790	184	147	37

DROPPER LENGTH MM	TOTAL QUANTITY	ORDER	ON HOLD
800	120	96	24
805	15	12	3
810	110	88	22
815	5	0	5
820	7	0	7
825	6	0	6
830	12	10	2
835	12	10	2
840	175	140	35
845	254	203	51
850	7	0	7
855	130	104	26
860	246	197	49
865	12	10	2
870	4	0	4
875	149	119	30
880	2	0	2
885	6	0	6
890	1700	1360	340
895	167	134	33
900	2	0	2
905	356	285	71
910	16	13	3
915	205	164	41
920	110	88	22

DROPPER LENGTH MM	TOTAL QUANTITY	ORDER	ON HOLD
930	190	152	38
935	73	58	15
940	53	42	11
945	157	126	31
950	8	0	8
955	239	191	48
960	72	58	14
965	41	33	8
970	12	10	2
975	51	41	10
980	64	51	13
985	143	114	29
990	2	0	2
995	14	11	3
1000	209	167	42
1005	6	0	6
1010	203	162	41
1015	270	216	54
1020	45	36	9
1025	21	17	4
1030	1	0	1
1035	244	195	49
1045	15	12	3
1050	184	147	37
1055	3	0	3

DROPPER LENGTH MM	TOTAL QUANTITY	ORDER	ON HOLD
1060	4	0	4
1065	58	46	12
1070	142	114	28
1075	16	13	3
1080	205	164	41
1085	30	24	6
1090	24	19	5
1095	12	10	2
1100	2	0	2
1105	8	0	8
1110	54	43	11
1115	17	14	3
1120	109	87	22
1125	11	9	2
1130	118	94	24
1135	30	24	6
1140	110	88	22
1150	7	0	7
1155	1	0	1
1165	17	14	3
1170	7	0	7
1175	1	0	1
1180	10	8	2
1185	108	86	22
1190	5	0	5

DROPPER LENGTH MM	TOTAL QUANTITY	ORDER	ON HOLD
1210	3	0	3
1220	1	0	1
1225	1	0	1
1235	109	87	22
1240	53	42	11
1245	2	0	2
1250	7	0	7
1255	3	0	3
1265	2	0	2
1275	2	0	2
1295	1	0	1
1300	6	0	6
1315	1	0	1
1320	1	0	1
1325	109	87	22
1340	110	88	22
1350	2	0	2
1355	4	0	4
1360	2	0	2
1375	2	0	2
1385	1	0	1
1390	1	0	1
1395	109	87	22
1400	1	0	1
1430	1	0	1

```
         DROPPER        TOTAL
DRC      LENGTH MM  QUANTITY      ORDER   ON HOLD
LEI      ========.=.==========.=========.========.
==            1525          2         0        2
              1730          2         0        2
              2025         10         8        2
                  - ----------- ---------- --------
                        15954     12567     3387
                         ..... END REPORT .....
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Overhead Contact System of Loadout Loops Specification

OVERHEAD CONTACT SYSTEM
OF
QUINTETTE AND TECK LOADOUTS
FOR
BRITISH COLUMBIA RAILWAY
TUMBLER RIDGE BRANCH LINE
50 kV ELECTRIFICATION

Canadian Pacific Consulting Services Ltd.
Montreal, Quebec
July 1983

1. SCOPE

This is a description of the Overhead Contact System (OCS) at the loadouts at Quintette and Teck.

2. GENERAL

There is a building at Quintette and two silos at Teck through which the coal train passes to be loaded, following which there is a non-electrified "daylighted zone" where the load is trimmed, then a latex building where the load is sprayed.

The general layout is shown on drawing no. 0-503790 "Quintette Loadout, Latex Build. and Clamshell Area, BCR Overhead Contact System".

3. DRAWINGS

Drawing No.	Title
0-503790-A	Quintette loadout, latex building and clamshell area, BCR overhead Contact system.
2-504755	Passage to daylight zone, assembly drawing.
2-504760	Insulator to neutral section, assembly drawing.
3-504761	Contact bar, assembly drawing
2-504160	Tensioning girder
2-504161	Tensioning girder
2-504739	Contact bar
2-504740	Contact bar
2-504741	Brackets for portal
2-504742	Portal
2-504743	Insulator bracket
2-504744	Holder of pull rods on contact rail
2-504745	Yoke
3-504746	Bracket for yoke
3-504747	Journal bearing for yoke
4-504748	Holder on for girder for insulator
4-504749	Shaft for pull rod
4-504750	Pull rod

Drawing No.	Title
4-504751	Securing plate
4-504752	Washer
4-504753	Mounting of insulator on girder for insulators and tensioning girder.
2-504754	Girder for insulators
3-504756	Bracket for stay crutch
4-504757	Holder on
4-504758	Stay crutch holder
4-504759	Stay crutch
2-504762	Safety chain for spring tensioning
3-504763	Tensioning spring
4-504765	Quantity list over components
1-504766	Modified section insulator

4. DESCRIPTION

4.1 The OCS between the building (or silos) and the "daylighted zone" has a fixed termination contact wire and a spring tensioned messenger wire.

The automatic tensioned OCS is dead-ended on the latex building side of the "daylighted zone".

Both the above terminations are detailed on drawing no. 2-504755.

Note that the spring is only in the messenger on the loadout building side of the "daylighted zone" and not in the auto-tensioned side.

4.2 Before the locomotive passes into the loadout buildings (or silos) the pantographs will be lowered automatically and raised automatically after passing through.

4.3 The OCS is dead-ended (terminated) to both sides of the loadout building (or silos) with a modified section insulator per drawing no. 1-504766 as shown on drawing no. 2-504760.

4.4 The contact wire height is adjusted by moving the bracket for yoke, drawing no. 3-504746, vertically in the tensioning girder, drawing no. 2-504161.

4.5 Tensioning girder per drawing no. 2-504161 is to be installed to the building wall by others.

4.6 Tension forces are 2 x 6 kN where the automatically tensioned OCS is dead-ended and 11 - 15 kN where the contact wire is fixed terminated and where the messenger is spring tensioned terminated.

4.7 The messenger shall be tensioned by the spring in accordance with the temperature graph of drawing no. 3-504763 according to the messenger temperature at time of installation.

4.8 The pantograph pan will not normally pass over the insulated part (epoxy resin rod, teflon covered) of the modified section insulator (drawing no. 1-504766). Should this happen, flash over to ground will not occur because of the 1,400 mm gap.

4.9 To obtain this 1,400 mm gap, the arcing horns, detail nos. 2, 4, 5 and 6 of drawing GVTO-504414 must be modified and relocated per drawing no. 1-504766.

4.10 The contact wire height external to the building is 6,500 mm increasing to 7,000 mm towards the "daylighted zone". After passing under the portal beam the pantograph will rise to its maximum position over the curved access bar (drawing no. 8-504739). At the far side of the "daylighted zone" the pantograph comes into contact with another curved access bar which lowers the pantograph to 7,000 mm above top of rail.

4.11 The OCS between the building and the "daylighted zone" is fed from the bypass feeder wire which is mounted on the portal poles. The feeder wire at Quintette is located at the opposite side from that of Teck. (Drawing no. 0-504790).

5. MATERIAL

Drawing no. 4-504765 lists the materials required other than the insulators listed as items 1, 2, and 3 on drawing no. 0-504790 and other than standard OCS wire and hardware.

Specification on Foundation and Pole Installation

REPORT ON

ELECTRIFICATION POLE FOUNDATION TEST PROGRAM

Prepared by: John C. Leighton,
Geotechnical Engineer

February 9, 1983

ELECTRIFICATION POLE FOUNDATION TEST PROGRAM

PURPOSE

To investigate several preliminary pole foundation designs, observing the practical aspects of construction, site installation, and performance under loading.

INTRODUCTION

The test program took place during December, 1982 and January, 1983 under the supervision of D. Carabetta and J. Leighton. All works were carried out in the equipment yard of Catre Industries Ltd. in north Surrey.

The site consisted of dense silty, sandy gravels to a depth of approximately 3 metres, overlying a more sandy sequence. The gravel contained cobbles ranging up to 150 mm in size. The groundwater table was approximately 1.5 metres below ground surface.

An open area of the yard was selected for the testing and the work area was delineated by two flagged lines 8 metres apart to represent a typical grade-top width.

OUTLINE OF WORK

On the first day, a wheel-mounted pile-driver placed two 12 x 12 "H" piles to a depth of 4.3 metres. The entire sequence of operations was timed and the blow-counts were recorded.

One pile was cut off level at the specified elevation above subgrade and prepared for welding. A steel plate with four pre-punched bolt holes was welded to the pile top and the first pole erected by bolting onto the plate. The second pile was roughly cut off at a fixed elevation in preparation for a cast concrete pile cap.

The second day involved augering 810 mm diameter holes for placement of a full length pole. An augering test was made in a clayey silt material in addition to those at the Catre site for comparative purposes. One full length pole was placed and cast in concrete. At the same time, concrete was cast for the pile cap and for two pre-formed pedestal bases.

After the concrete had cured, the third day involved excavating two holes with a backhoe and placement of the pre-cast bases. The bases were backfilled up to subgrade elevation.

The last phase of the program involved monitoring pole and footing deflections under simulated loading. Loads were applied incrementally and cycled up to the ultimate design moment. Readings were taken upon loading and relaxing of the structure.

A complete photographic record documenting the above activities is enclosed in a separate booklet.

OBSERVATIONS & DISCUSSION

1. Driven Pile Foundation

In general, the pile driving was impressive due to its speed and precision. A total of 20 minutes was required for the complete cycle of set-up, driving, break-down, and moving to the next position. Mobilization was fast and efficient and the equipment did not obstruct the grade to the passage of other traffic.

Despite the relatively coarse nature of the ground conditions, the pile was driven to full depth in 7 minutes and ended up only 20 mm off the intended centre-point. (Permitted tolerance is ± 100 mm.) The performance during this test would indicate that pile driving should be able to handle a broad range of ground conditions, providing necessary versatility for the varied conditions to be encountered on the Tumbler Ridge Branch Line.

The principal difficulty faced by pile-driving will be the unanticipated presence of isolated large boulders which stop driving or result in excessive deflection. For this reason, it would be recommended to have a pile-driver equipped with a vibratory driving head as this would permit pile extraction and re-driving where an unexpected obstruction is encountered.

One of the principal advantages of pile-driving is that it does not disturb the grade and will actually consolidate the surrounding soil. The presence of a high groundwater table does not pose an adverse problem to pile-driving. Furthermore, the pile should not be significantly affected by ground frost action due to the depth of pile penetration beyond the active frost zone and the low degree of frictional adhesion to the steel surface.

Pile driving presents an advantage in scheduling because the piles can be installed independently of other pole installation operations.

In general, the pile foundation exhibits excellent performance under loading. This is because the footing movement depends largely on the elastic deflection properties of the pile and not entirely on the lateral load-bearing resistance of the surrounding soil. For this reason, piles should perform well in a broad variety of soil conditions, and it should be possible to use lighter 10 x 10 piles.

When considering a design for pile-to-pole connection, several degrees of freedom are necessary in order to accommodate any twisting or leaning of the final pile top. Unfortunately, this precludes any reasonable form of direct mechanical connection. The following two connection methods were investigated:

(a) One pile top was cut off level and a steel foot plate welded on. The operation is simple, although the overhead welding is awkward and tedious, and results in a finished footing ready for pole mounting. The complete cutting, preparing, and welding sequence took one man 90 minutes to complete. Quality control of the welding will be important, but is not expected to be a major problem.

The principal advantage of this method is the high degree of flexibility. The plate can be adjusted to a twisted or leaning pile, yet the relative position of the holes will be consistently located with machine-shop precision. Any adjustment of pole plumb can be easily achieved with shims under the pole base. Two further cost saving features are the lack of ground preparation involved, and the absence of any concrete.

This footing design performed very well during the load testing and remained fully elastic throughout the loading cycle.

(b) the other pile top was partly excavated and a 1 metre high Sono-tube form placed around it. Four anchor bolts were fixed into a forming jig and placed inside the form. The Sono-tube was then filled with concrete, serving as the connecting medium between the pole base and the pile.

The principal advantage of this method is the ability to counter location shift of the pile by adjusting the position of the Sono-tube form. Also, the levelling nut arrangement of the anchor bolts permits very fine adjustment for levelling the pole base.

However, the use of small quantities of concrete introduces a high cost as well as the delay for concrete setting in the field. Also, the steps for excavating, forming and bracing involves several simultaneous tasks which require different pieces of equipment. The positioning and plumbing of the anchor bolts within the form is very critical, demanding careful and precise control when forming.

This footing performed very well during load testing since the concrete cap provided additional stiffness to the pile top.

2. Augered Footings

Prior to completion of the testing program, it was decided not to consider the augered foundation for the full length pole. Although it performed very well under load testing, it was eliminated due to practical difficulties of construction and its high cost. Therefore, no further discussion of this option will be included in this report.

3. Pre-Cast Pedestal Bases

These pre-cast bases are similar in concept to those used for highway and municipal lighting and traffic poles. Both a cylindrical shape (cast in a Sono-tube form) and a trapezoidal shape were made for comparative purposes. A backhoe was used to excavate a 2 metre deep hole for footing placement.

The main advantage of this type of footing is that it can be used in cases where it is not possible to drive piles. Also, it should be possible to have good control of concrete quality and there are no curing delays in the field.

Unfortunately, this method results in digging up a large section of the grade, completely blocking the grade to all other traffic. If the water table is encountered within the hole, it is almost impossible to achieve good results since it becomes very difficult to prepare a level base in the bottom of the hole.

The principal drawback of this type of footing is that its success depends entirely on the quality of compaction achieved in the backfilling operation. Uniform placement of backfill material and proper compaction is difficult within the confines of a trench-like backhoe hole. This would imply that it may be necessary to deliberately over-excavate the hole to permit better backfilling control. Furthermore, the orientation of the backhoe hole is not favourable for bending moment resistance.

If the backfill is a good free-draining material surrounded by less pervious soil, the excavation will become a water sump in the grade. Also, this type of footing could be susceptible to frost heaving action due to its shallow depth of embedment.

Loading tests pointed out the extreme importance of backfill compaction control. In the field tests, backfill control was poor due to the presence of water in the excavation and an inappropriate tamping device. Footing deflection under load is completely inelastic, resulting in a permanent displacement of the footing.

RECOMMENDATIONS

Based on the results of the field testing program and consultation with people involved in construction, it is recommended that the driven "H" pile and welded plate design be selected as the primary foundation type. It offers great speed and flexibility for installation at least estimated cost.

Despite the drawbacks, a pre-cast pedestal base will be necessary for those locations where it is not possible to drive a pile but a hole can be excavated. The cylindrical design is recommended for ease and cost savings in forming, transport and handling.

In addition to the above foundation types, a design for a footing on rock has been prepared. This design is a typical grouted anchor foundation and it was not included in the testing program.

BRITISH
COLUMBIA
RAILWAY

PART IV

SPECIFICATIONS

Section 1 - General Requirements
Section 2 - Foundations
Section 3 - Poles
Section 4 - List of Drawings

Initialled by: __________ Contractor __________ Company

SECTION 1 - GENERAL REQUIREMENTS

1.1 Scope of Work

The work of this Contract covers the installation of the foundations and poles to support the Overhead Contact System associated with the electrification of the Tumbler Ridge Branch Line from Km 79.65 to Km 130, and including a siding at Km 99 and two loadout loops at about Km 113 and Km 129.3. The work will include the installation of Company supplied pre-cast concrete and pile foundations, the supply and installation of rock anchors, and installation of Company supplied poles.

1.2 Work by Others

1.2.1 General

The Company intends to carry out other works in the area, whether with its own forces or Others, as indicated on the Construction Schedule. In particular, the following work will be running concurrently with the Contract:

(a) Driving of the Wolverine and Table tunnels.

(b) Maintenance of the main access roads, except that the *
Contractor will be responsible for any damage he causes. *

(c) Construction of the Km 80.1 bridge is scheduled for completion June 1, 1983.

(d) Construction of the Two Creek Bridge at Km 111 and the Bullmoose Creek Bridge at Km 116 are scheduled for completion June 30, 1983.

(e) Construction of the Wolverine River bridge at Km 118 and the Murray River bridge at Km 121 are scheduled for completion June 30, 1983.

(f) Overhead Contact System hardware at the bridges will be installed by Others.

1.2.2 Tracklaying and Ballast

Tracklaying and ballasting are critical activities on the project and will be carried out by B.C. Railway forces. The project schedule Drawing No. RA1/7-21480 indicates the sequence of activities which must be followed to meet the completion date. The installation of poles and foundations must be completed before tracklaying. The time frames within which this work must be carried out are as follows:

SECTION	TIME FRAME
Km 79 - Km 92	June 12, 1983 to July 10, 1983
Km 92 - Km 116 (including Teck Loop at Km 113)	May 15, 1983 to June 15, 1983
Km 116 - Km 130 (including Dennison Loop at Km 129.3)	July 8, 1983 to August 6, 1983

The Contractor must work progressively from one end of each section in order to allow sub-ballast work (by Others) to follow sequentially.

1.3 Site Location and Access

The construction Site is located approximately 120 kilometres south of Chetwynd, B.C. Access to the Site is available via the existing gravelled public road.

1.4 Site Restrictions

The bridges being built will not be available for use by the Contractor.

Fire-arms shall not be permitted in the camp or on the job Site.

1.5 Mobilization and Demobilization

Mobilization shall mean moving on to the jobsite all personnel, materials, services, transportation, equipment, supplies and temporary structures required to perform the Work.

Demobilization shall mean removal from the site of all items mobilized to the Site which have not been incorporated into the Work, temporary camps and other structures, and rubbish and waste materials from his operations.

1.6 Contractor's Camps and Offices

The Contractor shall provide his own temporary camp, garages, maintenance shops, office buildings, or other facilities as may be required, and shall assemble and erect such plant and equipment at the Site.

The Contractor shall be completely responsible for the provision of all facilities and services required to provide board and lodging for his labour force and the transportation of his labour force between their accommodation and work areas.

GENERAL

2.1 Scope

This Section refers to the work required to install the Foundations for the catenary poles.

Without limiting the generality of the foregoing, the work includes the following:

- Receipt and handling of Company supplied materials, including steel piles, pre-cast concrete pedestals, baseplates and rock anchor plates.
- Installation of the three (3) main types of foundations.
- Pile driving.
- Cutting and welding of piles.
- Supply and installation of rock anchors.
- Excavation, backfill, compaction, and clean-up associated with the foundation installation.

2.2 Codes

Welding shall be performed in accordance with CSA W59.1 1982, and by welders qualified under CSA Standard W47.

MATERIALS

2.3 Material Supplied by Company

The following materials will be supplied by the Company at the locations indicated:

2.3.1 Steel Piles

HP 10 x 42 steel piles for use in Type I foundations will be supplied in 50 ft. and 40 ft. lengths at the B.C.R. Wolverine Camp at Km 98.

2.3.2 Baseplates

Baseplates are steel grade G40.21-M-300W, 20 mm thick with four (4) bolt holes, and will be supplied in bulk at the B.C.R. warehouse in Prince George, B.C. Baseplates for poles C130 x 10, C130 x 13, and C150 x 16, measure 700 mm x 500 mm. The baseplates for the C250 x 30 portal poles measure [illegible]00 mm x 600 mm, and will be stamped to differentiate them from the other baseplates.

Initialled by: ________ ________

Contractor Company

2.3.3 Rock Anchor Plates

Rock anchor plates have three (3) bolt holes, and will be supplied in bulk at the B.C.R. warehouse at Prince George, B.C.

2.3.4 Type II - Pre-cast Concrete Pedestals

Pre-cast concrete pedestals, each one with four (4) anchor bolts, complete with nuts and washers will be available for turnover to the Contractor at the B.C.R. Wolverine Camp at Km 98.

2.3.5 Backfill Material

Backfill is material which is less than 230 mm in its greatest dimension, free of deleterious matter, and non-cohesive in nature.

The Contractor is to first use whatever acceptable backfill material is available from the material excavated from the grade. Extra material is obtainable at no charge from one of the Company's pits within a haul distance of 7 km.

2.4 Material Supplied by Contractor

All other materials shall be supplied by the Contractor, of which the following are included:

2.4.1 Rock Anchors

Rock anchors shall be DYWIDAG or approved equal to ASTM A722, complete with nuts.

2.4.2 Resin

Resin cartridges shall be supplied to the manufacturer's recommended viscosities and setting times for the expected temperature range.

EXECUTION

2.5 Pole Locations and Types

The pole locations and types are identified by number on the Drawings, together with the type of foundation expected.

2.6 Types of Foundation

There are three (3) main types of foundations to support the catenary poles:

Type I - driven steel piles.
Type II - pre-cast concrete pedestals.
Type III - resin grouted rock anchors.

The preferred type of foundation is the Type I - driven steel pile; however, where this type has initially been indicated on the Drawings, it may be necessary to change to either of Types II or III, if it is not possible to drive the pile to the required depth. Similarly, where a Type II has been indicated, it might be necessary to change to a Type III if rock is encountered above the minimum depth required for the embedment of the pre-cast concrete pedestal.

The Contractor should be aware that the C250 x 30 Portal Structure poles are installed on baseplates or pre-cast concrete pedestals as applicable, which are of a size different from those for the C130 x 10, C130 x 13, and C150 x 16 pole types.

2.7 Pole Types and Colour Coding

Appendix C, Foundation and Pole Summary, summarizes the colour coding, marking, and sizes for the catenary poles and the accessories for attachment to the various types of foundations.

2.8 Tolerances

The foundations shall be installed such that the poles can be fastened to them within the following tolerances:

(a) In the horizontal plane:

Nominal offset from, and normal to, centreline of rail,	3500 mm ± 100 mm
except for up to ten (10) locations where tolerance is	3500 mm ± 50 mm
Location of poles along the track, pole to pole, except that the maximum span between poles of nominal span 70 m, shall not exceed 70.5 m	± 500 mm

(b) In the vertical plane:

Vertical distance of underside of pole base below top of rail	600 mm + 100 mm - 0 mm

Note: For superelevated track, top of rail is the average of the two tops of rail.

2.9 Type I - Driven Steel Pile

2.9.1 Application

Type I foundations are intended to be used in earth and rockfill sections wherever the pile can be driven to the required depth or to a lesser depth acceptable to the Engineer.

2.9.2 Handling

Piles shall be handled so as to avoid damage.

All surplus piling and all pile cut-offs of length suitable for use in Type III foundations, shall remain the property of the Company.

2.9.3 Equipment

The Contractor may use a vibratory attachment with his pile driver, except that vibration may not be used when saturated plastic material is encountered.

2.9.4 Pile Driving

Piles shall be driven so that the two flange portions of the H-pile are parallel to the grade centreline within 30°. The piles shall be driven without excess deformation of their heads, and such that the deviation from the vertical does not exceed 1 inch per foot length.

2.9.5 Pile Welding

After driving to the required elevation, the piles shall be cut off at the correct elevation and chamfered ready for welding of the baseplates.

Welding shall conform in quality and workmanship to the latest AWS D1.1 and CSA W59.1 1982. Welders shall be qualified under CSA Standard W47.

2.9.6 Unacceptable Piles

Where bedrock, boulders or other large obstructions make it impossible to drive the pile in the desired location, the Engineer will direct the Contractor to withdraw the pile, and replace it with a Type II or III foundation.

2.9.7 Remedial Work

In the event that the Contractor fails to achieve the tolerances in horizontal location on the baseplates as specified in Section 2.8, the Contractor shall perform remedial work at no cost to the Company, and subject to the approval of the Engineer.

2.10 Type II - Pre-cast Concrete Pedestals

2.10.1 Handling

The pre-cast concrete pedestals shall be handled in a manner such as to avoid damage to the concrete and the threads of the anchor bolts. A lifting lug is provided.

2.10.2 Excavation

The hole for the pedestal shall be excavated such as to minimize damage to the grade. The Contractor's method of, and equipment for, excavation of the grade is subject to the approval of the Engineer; use of a backhoe would be acceptable. Excavated material not suitable for backfilling is to be wasted along the slope of the grade.

The bottom of the excavation shall be made level, with additional material as necessary, and compacted ready to receive the pre-cast concrete pedestal.

2.10.3 Backfilling

Only materials free from plastic soils are to be used for backfilling. The backfill is to be brought up in lifts of 300 mm evenly around the pedestal to the original line and grade, and compacted to 95% of the density of the original grade material. The plumbness of the pedestal is to be maintained whilst backfilling.

2.10.4 Geotextile Fabric

The Contractor is advised that geotextile material was installed in certain parts of the grade. In excavating for the foundations, the Contractor is to avoid disturbing the fabric any more than is necessary; in backfilling, the Contractor shall make reasonable efforts to return the fabric to its original position.

2.11 Type III - Rock Anchors

2.11.1 Installation

Type III foundations require excavation to rock, the drilling of three (3) holes vertically into rock a minimum of 2 m at each location, and the full length installation of #10 Dywidag rock anchors, resin grouted for the full length of the anchor. The requirements for excavation and backfilling in Sections 2.10.2 and 2.10.3 respectively, shall apply.

The holes shall be located such that the shorter side of the rock anchor plate can be installed parallel to the centreline of the track; the side of the anchor plate having the two holes shall always be located furthest from the track centreline, except where the foundation is located on the inside of a curve, where the opposite will obtain.

2.11.2 Resin Cartridges

The resin cartridges shall be stored in a well ventilated, dry area, and protected from excessive heat or cold during storage. Not more than 2 months' supply of cartridges shall be kept on hand and the manufacturer's recommended shelf life shall not be exceeded. Resin cartridges that show signs of hardness or other indications of deterioration shall not be used. Resin encapsulated anchors shall be installed in accordance with the manufacturer's recommended viscosities and setting times for the expected temperature ranges.

2.11.3 Spacer Piece

The spacer piece between the underside of the foundation baseplate and the rock anchor plate is to be made using a suitable length of H-pile.

2.12 Clean-Up

The work of installation of foundations shall be performed without damaging the grade, and the grade shall, as near as possible and to the satisfaction of the Engineer, be returned to its original condition. Any damage to the grade caused by the Contractor's equipment shall be repaired in a timely manner such as to avoid any delays in the placing of sub-ballast by Others. * * * * *

PAYMENT

2.13 Payment

2.13.1 General

Payment for foundations shall be made at the applicable unit price per foundation entered in the Form of Tender.

2.13.2 Type I - Pile Foundations

The unit price for each Type I foundation shall be accepted as full compensation for everything necessary to install the foundations in the required location to the specified tolerance. No separate payment will be made for any labour or material required for any remedial work as detailed in Section 2.9.7; unsuccessful piles are not included in this unit price.

2.13.3 Unsuccessful Piles

Piles which are deemed unacceptable and are required by the Engineer to be withdrawn in accordance with Section 2.9.6 shall be paid for at the applicable Additional Unit Price in the Form of Tender. This shall include withdrawing the pile and re-using the material as appropriate. *

2.13.4 Type II - Pre-cast Concrete Pedestal Foundations

The unit price for each Type II foundation shall be accepted as full compensation for everything necessary to install the pre-cast concrete pedestals in the required location to the specified tolerance, including the provision and compaction of backfill material.

Initialled by: ____________ ____________
Contractor Company

2.13.5 Type III - Rock Anchor Foundations

(a) Drilling for and installation of rock anchors to a depth of 2 m:

The unit price for each Type III foundation shall be accepted as full compensation for everything necessary to provide Type III resin grouted rock anchor type foundations in the required location to the specified tolerance, with the rock anchor holes drilled a normal minimum of 2 m into rock, including the provision and compaction of backfill material.

(b) Drilling for and installation of rock anchors to a depth greater than 2 m:

Where the Engineer determines that longer rock anchors are required to be installed in rock to a length greater than 2 m, payment will be made at the unit price of pay item 2.3 detailed in Section 2.13.5(a), and in addition at the Additional Unit Price for Type III Foundations with longer rock anchors, under pay item 5.0.

Payment for drilling a set of three (3) holes and installation of the longer rock anchors will be made under pay item 5.0 for each 0.5 m increment over 2 m, and shall include for everything necessary to provide the longer rock anchor installation.

SECTION 3 - POLES

GENERAL

3.1 Scope

This Section refers to the work required to install the catenary poles for the Overhead Contact System.

Without restricting the generality of the foregoing, the work includes the following:

- Receipt and handling of Company supplied materials including poles, nuts and bolts.
- Installation of poles.
- Marking of poles.

MATERIAL

3.2 Material Supplied by Company

The following materials will be supplied by the Company at the locations indicated:

(a) Prefabricated Galvanized Poles, each having the approximate weight and length indicated, shall be available from the B.C.R. Wolverine Camp at Km 98: * *

Pole Type	Weight (lbs)	Length	*
C130 x 10	630	31'-3"	*
C130 x 13	785	31'-3"	*
C150 x 16	960	33'-0"	*
C250 x 30	1600	33'-0"	*

(b) Attachment bolts, washers, lock washers and nuts to attach the poles to the steel base plates are galvanized, and will be supplied in pails. They will be available at the B.C.R. warehouse in Prince George, B.C.

3.3 Colour Coding

The baseplates and poles shall be colour coded or otherwise marked for identification (see Appendix C, Foundation and Pole Summary).

EXECUTION

3.4 Handling

Poles shall be lifted with soft rope or web slings and supported during transportation and erection in a manner that will preserve the galvanized finish and prevent deformation of the structure. Damaged poles shall not be used except with the written approval of the Engineer.

Touch-up to the surface finish shall be by application of Galvacon zinc-rich paint, or approved equal. Repair of structural damage shall be performed as directed by the Engineer.

3.5 Erection of Poles

Poles shall be attached to the steel baseplates and pre-cast concrete bases with the bolts and nuts supplied by the Company, and plumbed to the specified tolerances. When the pole is in its final position, the bolts are to be tightened "snug-tight", as defined in CSA Standards.

3.6 Erection Tolerance

Poles shall be erected to a vertical tolerance of 1:200 maximum off vertical in any direction. Poles erected on the inside of curves with a degree of curvature of 2° or more shall be inclined toward the track at a vertical inclination of 1:100 with the same tolerance.

3.7 Cutting and Drilling of Poles

Poles shall not be cut or trimmed to accommodate deficiencies in the foundation placement. If site drilling is required, holes shall be drilled or reamed. Burning or grinding shall not be permitted. The holes shall have all burrs removed and bare metal shall be touched up with zinc-rich Galvacon paint or approved equal.

3.8 Numbering of Poles

The Contractor shall paint the pole number on both sides of the pole on the flange braces, perpendicular to the track centreline and approximately 2.0 metres above top of rail.

Numbers shall be stencilled with black enamel paint and shall be a minimum of 50 mm in height.

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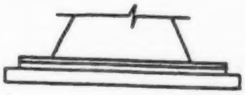
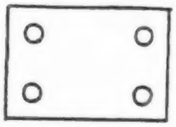
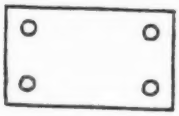
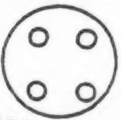
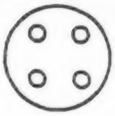
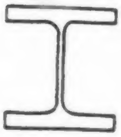
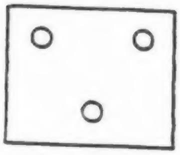
APPENDIX - C

FOUNDATION AND POLE SUMMARY:

CATENARY POLES				
TYPE	C 250X30	C150x16	C130x13	C130x 1
Colour Coding	White	Blue	Yellow	Red
Base Plate Size	700mm x 600mm			
Baseplate hole Ø	44 mm Ø	38 mm Ø		
FOUNDATION FOOTPLATES				
Marking	Stamped			
Size	700mm x 600mm	700mm x 500mm		
Hole Dia.	44mm Ø	38 mm Ø		
CONCRETE PEDESTALS				
Colour Coding	White			
Anchor Bolt Dia.	1-1/2" Ø	1-1/4" Ø		
Block Height	2.6m	2.3m		
PILING				
Size	HP 10x42			
Delivered Length	40 ft. & 50 ft. lengths			
ROCK ANCHORS				
Number/pole	3	3	3	3
Diameter	#10	#10	#10	#10
Depth in rock	Varies; 2m min			
ROCK ANCHOR PLATES				
Plate Size	700mm x 600mm			
Hole Diameter	38mm			

POOR

QUALITY

ORIGINAL